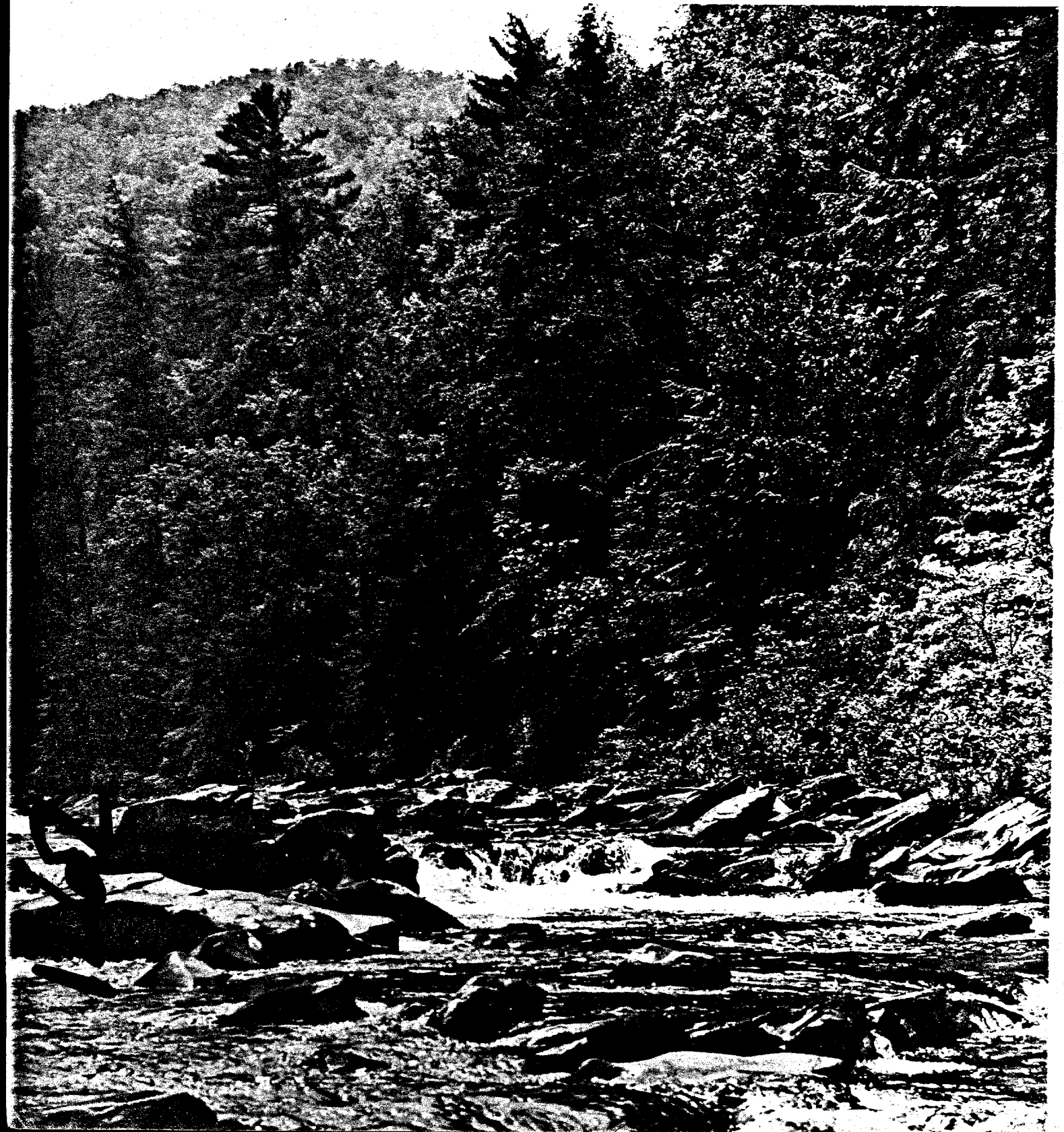


# MERCURY CONTAMINATION in TENNESSEE

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## MERCURY CONTAMINATION IN TENNESSEE

### INTRODUCTION

It may seem somewhat ironic that a discussion of the mercury problems in Tennessee would be prefaced by a discussion of mercury contamination in Japan and Almagordo, New Mexico. However the entire problem of mercury pollution can better be brought into perspective by this approach.

### HISTORY OF THE PROBLEM

Historically, the first well defined and documented case of mercury poisoning occurred in Minimata, Japan. Strange unexplained phenomena were noticed. Fish floated on the surface, shellfish and seaweed died, and sea birds were seen falling into the water from full flight. The frequency of fish kills increased. Cats and dogs developed a syndrome referred to as "Dancing Disease". Behavioral patterns included salivation, loss of equilibrium, and convulsions. Some whirled in large circles, collapsed, and died violently.

Investigations began and human cases were discovered. Fear of contagious disease broke out, and persons with mercury poisoning were shunned by their peers. Studies showed that the disease was caused by heavily metal poisoning from eating fish from Minimata Bay, but it was not until 1959 that mercury was identified as the causative agent. By 1961 some 121 cases had been confirmed, resulting in 46 deaths. One-half were adults, one-third were children, the remainder were fetal fatalities. Eleven of the adults died within one year after the appearance of the first symptoms, which included, but were not limited to: Numbness and tingling of the hands, lips and feet, disturbance of speech, concentric constriction of vision, impairment of hearing and muscular coordination. Also, there were emotional disturbances. Fetal cases often result in mental retardation or a Cerebral-Palsy like condition accompanied by convulsions.

Most of the people affected were fishermen or persons that very often included fish in their diet. Studies showed that fish from Minimata Bay contained from 1 to 20 ppm mercury on a wet weight basis. It should be noted that families frequently ate the liver of fish that contained 2 to 3 times this concentration. Mud samples from the Bay revealed concentrations from 2,010 ppm (near the discharge of the Chisso Company) to 133 ppm near the mouth of the Bay.

Of 100,000 Japanese living in the Shiranui Sea area (of which Minimata Bay is a part) there were 798 confirmed cases of mercury poisoning that resulted in 107 deaths. By 1974 there were 2,800 additional cases awaiting confirmation. Other environmental problems were noted. Ornithologists in Sweden reported drastic reductions in the bird population. The cause was determined to be the result of eating seed that had been treated with methyl mercury. This study, in turn, sparked other investigations that led to the discovery of high concentrations of mercury in fish were made by Swedish scientists as a result.

Then on March 24, 1970, Canada ordered the destruction of 12,000 pounds of commercially caught Walleye from Lake St. Clair because of excessively high levels of mercury. This resulted in the closing of Lake St. Clair to commercial fishing, and involved the United States in that Lake St. Clair empties into Lake Erie.

In October of 1969 the United States experienced a mercury poisoning incident in Alamogordo, New Mexico, which involved a family that had obtained surplus seed grain, and fed it to 18 hogs, of which 14 became ill with blindness and gait disturbance. Twelve of the 14 died, and the survivors failed to regain their vision. One hog that seemingly

was well when butchered was eaten daily from October to December by seven of the nine family members. The eight year old girl became ill and was hospitalized with symptoms of mercury poisoning. Two weeks later the 13 year old boy developed the same illness and was followed by his 20 year old sister. It was at this point that they discovered that the causative agent was mercury. All of these patients were treated and survived, but remained severely debilitated because of neurological damage, which when caused by mercury poisoning is irreversible.

Analysis of the grain, pork, and serum of the patients showed mercury concentrations of 32.8 ppm in the grain, and 27.5 ppm in the pork. Serum levels were 1.92 for the young girl, 2.91 for the 13 year old boy, and 2.78 ppm for the 20 year old, respectively. Suzuki in Japan has shown from his studies that 20 ppm mercury in the human brain causes the manifestation of classic symptoms of mercury poisoning.

#### AWARENESS OF THE MERCURY PROBLEM IN TENNESSEE

In 1969 the Division of Water Quality Control became alarmed by the fact that the State was faced with a new pollution problem of major proportions, and this was worsened by the insidious nature of mercury. There was great concern that some of the major reservoirs would have to be closed to fishing, and that certain industries might have to shut down. The Division had maintained a broad surveillance program for many years. However, these investigations had failed to demonstrate significant levels of mercury in the water. But with the world-wide exposure of the mercury problem, it was decided that the Division should initiate its own investigation. After "gearing up" for the new problem even with the sophisticated instrumentation that we now have (but did not have at that time), measurable concentrations of mercury in water are seldom found. Greater concentrations of mercury are found in the sediment. However, there is not a homogenous distribution nor is there

any reproducible pattern of sediment movement.

#### THE FOOD CHAIN

Biomagnification occurs in the food chain. This is particularly true for the phytoplankton, zooplankton and fish. Once discharged into a stream mercury deteriorates very slowly, and even more so in a reservoir. It may persist for years. Prior to the Minimata incident, it was generally assumed that materials with as great a density as mercury settled out on the bottom of the stream, and remained there indefinitely in an innocuous form. Of course these assumptions have been proven invalid.

#### CHEMICAL PROPERTIES OF MERCURY

As an element, mercury is classified as a metal. It has such typical metallic characteristics as being a good conductor of heat and electricity. It forms cations by the loss of electrons, and readily forms basic oxides and hydroxides. It is ubiquitous in nature, which causes it to exert an important environmental influence on the air, water, and soil. Its presence may be in conjunction with sulfide ores (Zn and Cu). It occurs in certain shale and clay formations, phosphorites, limestones, soils, coal, petroleum, and volcanic eruptions. These natural sources contribute to the environmental mercury burden, but the real problem comes from industrial processes. It has been estimated that 163 million pounds of mercury have been consumed in the United States since the turn of the century.

## MAJOR CONTRIBUTORS TO THE MERCURY PROBLEM IN TENNESSEE

The chlor-alkali industry has been involved directly with most of Tennessee's mercury problems that have been studied. There are numerous other industrial users of lesser significance, and some major ones that have not been tied to a specific source. The chlor-alkali industry has used some 1.3 million pounds or 23.1% of the total amount of mercury. The production of chlorine and caustic soda is by the mercury cell method. The biggest losses to the environment have resulted from "poor housekeeping". For instance the Olin Matheson Company was loosing 100 lbs. of mercury per day to the Hiwassee River in 1970. This amount was reduced to  $\frac{1}{4}$  lb. by turning the necessary valves and practicing better clean up. This was accomplished without major expenditures and resulted in over  $\frac{1}{4}$  million dollars in savings to the company, and more important was the reduction of the pollution load to the stream.

Undoubtedly there may be more major, but subtle, contributors to the state's overall burden from mercury pollution. End results from mercury pollution have essentially the same impact on the total environment whether it comes from a small volume of highly concentrated waste or from a large volume of a more dilute waste that is similar in content and distribution. Both are pollution.

Mercury is found in varying concentrations in coal, depending on the grade and area that it was taken from. Studies have indicated that in facilities such as TVA steam plants that much of the mercury from burned coal goes out the stack as vapor. Its fate is largely unknown; however, it is reasonable to assume that a portion of it will eventually reach the aquatic environment. A large amount of fly ash is produced by these plants and comes in contact with the water. The amount of mercury leached from the material is unknown, but with very dilute concentrations, in such quantities the overall contribution to the environment could be considerable.

#### THE SELENIUM PROBLEM

Another complicating aspect of the mercury problem in Tennessee in relation to steam generating plants is the selenium content of coal. Selenium is somewhat similar to arsenic in chemical and physical properties, and it also reaches the watercourse in a manner similar to that of mercury. In 1974 Huckabee and Griffith tested the toxicity of mercury and selenium, using the hatchability of fish eggs as a measure of toxicity. They found that 5.0 ppm selenium did not prevent hatching of the eggs, nor did 2.0 ppm mercury. But combinations of the two elements killed over 80% of the eggs with only 1 ppm selenium and 1 ppm mercury. This synergism has potentially

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serious implications for Tennessee, since the two elements are usually associated with and contained in coal ash. Recently we expanded this line of testing and found that Green Sunfish begin dying at the end of 96 hours in a solution containing 4.7 ppm selenium and 0.031 ppm mercury. At the end of 7 days all fish were dead in concentrations of 2.6 selenium and 0.015 ppm mercury.

#### FORMS OF MERCURY

The action of mercury in the environment is complex. A basic overview is necessary to understand its pathways into the biological system. Mercury occurs in many forms, but can be grouped into 3 major types:

- a. Elemental Mercury
- b. Phenyl Mercury
- c. Bivalent Mercury

Elemental Mercury is only sparingly soluble in water. It settles rapidly to the bottom of the water course.

Phenyl Mercury Compounds adhere to fibrous material and silt particles. These compounds may be broken down to the bivalent state and in this form can easily be methylated. It is the methyl mercury compounds that move in the biological processes up the food chain, and cause the problems associated with mercury poisoning.

#### THE METHYLATION PROCESS

This methylation process is the key which had not been found prior to Minimata. Since then studies have indicated that methylation occurs in the bottom sediments from the activity of microorganisms. The most active

site is near the sediment surface. Benthic organisms such as burrowing mayflies, dragonflies, and freshwater clams may cause the process to occur at deeper levels of the bottom deposits than otherwise might be the case. A study by Jernelov of Sweden in 1970 showed that methylation occurs in the slime on the bodies of fish. Under experimental conditions, he found that almost total methylation of a mercury compound added to the test tanks took place within 2 to 4 hours.

The rate of methylation in nature is doubtless dependent on many things:

A) One of the primary influencing factors is pH. Lower pH values accelerate the methylation process which accelerates accumulation of the methyl mercury in the food chain.

B) Dissolved Oxygen levels affect the rate of methylation anaerobic conditions accelerate methylation, but frequently may result in the formation of  $H_2S$ , which may cause mercuric sulfide formation. When this occurs, little or no methylation follows. So from the practical standpoint, more methylation occurs under aerobic conditions. The passage of methyl mercury along the food chain is complex and not limited to a single pathway of travel. A series of transport methods was illustrated by Hartung.

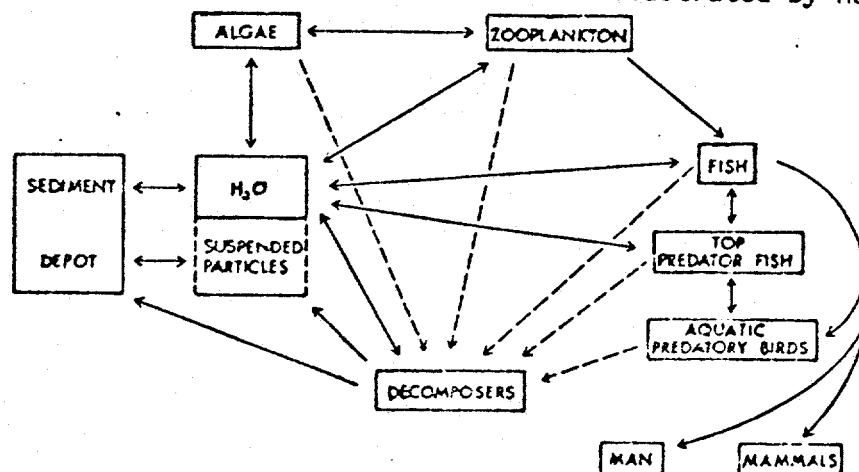


Figure 1: Environmental Dynamics of Hg in Aquatic Communities: The Role of Food Chains

- A) It should be noted from this diagram that in most instances organisms can derive their mercury burden from more than one source.
- B) Mercury compounds are interacted into the lower trophic levels from the water to both the phytoplankton and the Zooplankton, which are consumed by organisms of the next trophic level.
- C) Eventually top prebators accumulate that which has been passed up the chain.
- D) Man comprising the top of the food chain consumes fish from the highest trophic level, and the mercury deposit is thus passed to him.

#### SETTING UP THE MONITORING PROGRAM

In November 1970 the Division of Water Quality Control initiated its mercury monitoring program. Since chlor-alkali plants were highly suspect, it was only natural to begin the program on the Hiwassee River. Sampling was done in conjunction with TVA's biologist. Initially analysis were made by DOWOC, FDA, TVA, EPA, and one commercial laboratory. Replicate samples were run by each laboratory. Good correlation was obtained by all participants, and participation was discontinued by FDA and the commercial laboratory. EPA reduced its participation to running quality control analysis on 10% of the samples. After completing the initial phase of the sampling program, the DOWOC and TVA analyzed alternate specimens. Muscle, liver and kidney tissues of game fish have been analyzed by DOWOC, with muscle only of rough fish only, being analyzed.

#### SHOW STATE MAP WITH DISTRIBUTION OF SAMPLING STATIONS

Sampling stations were chosen at Hiwassee River Miles 13 and 7.5, and Tennessee River, Mile 495 above the mouth of the Hiwassee River, and Mile 490 below the confluence of the Hiwassee and Tennessee Rivers. Results from the first group of samples did not warrant closing these streams to fishing. It was decided that additional stations should be set up across the state to determine where the problem areas were. By mid-1971, stations which could be sampled regularly, based on the probability associated with potential sources, were established. The stations chosen were as follows:

1). North Fork of the Holston River, Mile 7.0 just upstream from Kingsport. The source of contamination for this station was the Olin Matheson Company in Saltville, Virginia. The plant was later closed, and the discharge discontinued. However, the problem still remains in the sediment.

2 and 3). Two stations were set up on Boone Reservoir, one on the Watauga Arm and one on the South Holston Arm. Sources here were allegedly associated with a slimicide seeping from steel barrels that had been sold by a nearby paper company to float private boat docks. Mercury levels at these two stations were always low, and eventually the stations were discontinued.

4). Hiwassee River, Mile 13, near Charleston, Tenn., this station was chosen because of an upstream chlor-alkali plant belonging to Olin Matheson Company.

5). Tennessee River, Mile 490. This station was chosen to measure the influence of the Hiwassee River on Chicamauga Reservoir.

6). Tennessee River, Mile 210 - located in Pickwick Reservoir near the Alabama State Line, and just above Pickwick Dam. The source of contamination for this station is the Diamond Shamrock Company in Alabama. It is also a chlor-alkali plant.

7.) Tennessee River, Mile 157 - located at Clifton, Tennessee in the upper end of Kentucky Reservoir. Diamond Shamrock was also the primary suspected source of contamination for this area. This station is also only a few miles below the Tennessee River Pulp and Paper Mill at Counce, Tennessee.

8). Tennessee River, Mile 60 - located below Paris Landing State Park at Boswell's Landing, and just above the Kentucky state line. It has the same pollution sources as stream miles 210 and 157. It is also below the New Johnsonville industries and TVA steam plant.

Additional studies have been made on a "grab sample" basis across the state since 1971. These included Cherokee Reservoir, Mile 89, Little River, Douglas Reservoir, Miles 32.8 and 57.0, Old Hickory Reservoir, and the Duck River. These investigations did not show any serious "Hot Spots".

#### GRAPHS AND TABLES

A series of Graphs and Tables have been prepared to provide a rapid visual summarization of the data. Graphs I through VI (a) depict the arithmetic means and maximum values of mercury levels in muscle tissue of all individual fish in each species collected at the regular stations.

by catfish in one specimen which attained a level of 5.0 ppm. Redhorse suckers had the next highest level with 3.6 ppm or 7 times the MPL. There were 83.3% of the rough fish in 1973 that exceeded the MPL and 60% in 1974 and 1975.

## SUMMARY

After looking at the data, the next logical question is where do we go from here? How long will it take for the mercury level to decline to the point that it is no longer a problem, or what can we do to hasten the process? These questions have not been answered yet, at least not satisfactorily.

Clinical studies have shown that mercury elimination from the human body is very slow. Elimination from fish is also slow. In a study in Finland using radioactive tracers, fish required 400 days to rid the muscle tissue of  $\frac{1}{2}$  of its mercury burden after removing them from the source of contamination. The test animals were perch and pike. Studies conducted in our laboratory showed that there was no reduction in mercury levels as a result of cooking the fish.

After the source of pollution has been removed, if cycling could be stopped, the problem could be lessened. But the question arises as to how? A study in Sweden which has had the problem for a number of years showed that in one lake mercury levels were still high after 45 years.

Some of the methods that have been suggested to speed the process of decontamination or interruption of cycling are:

1. Cover the bottom with clay or silica which in essence means "bury it".
2. Pollute the water with sulfide compounds so that mercuric sulfate would be formed thus eliminating methyl-mercury formation.
3. Add hydrogen sulfide to change the form. However, hydrogen sulfide is itself toxic to fish and aquatic life.

4. Raise the ph to decrease the rate of methylation and increase the production of dimethyl mercury. This would be released to the atmosphere however, and would only transfer the problem.

These solutions are all impractical.

### Bibliography

From: Cycling and Control of Metals - Published by the EPA the following papers were used:

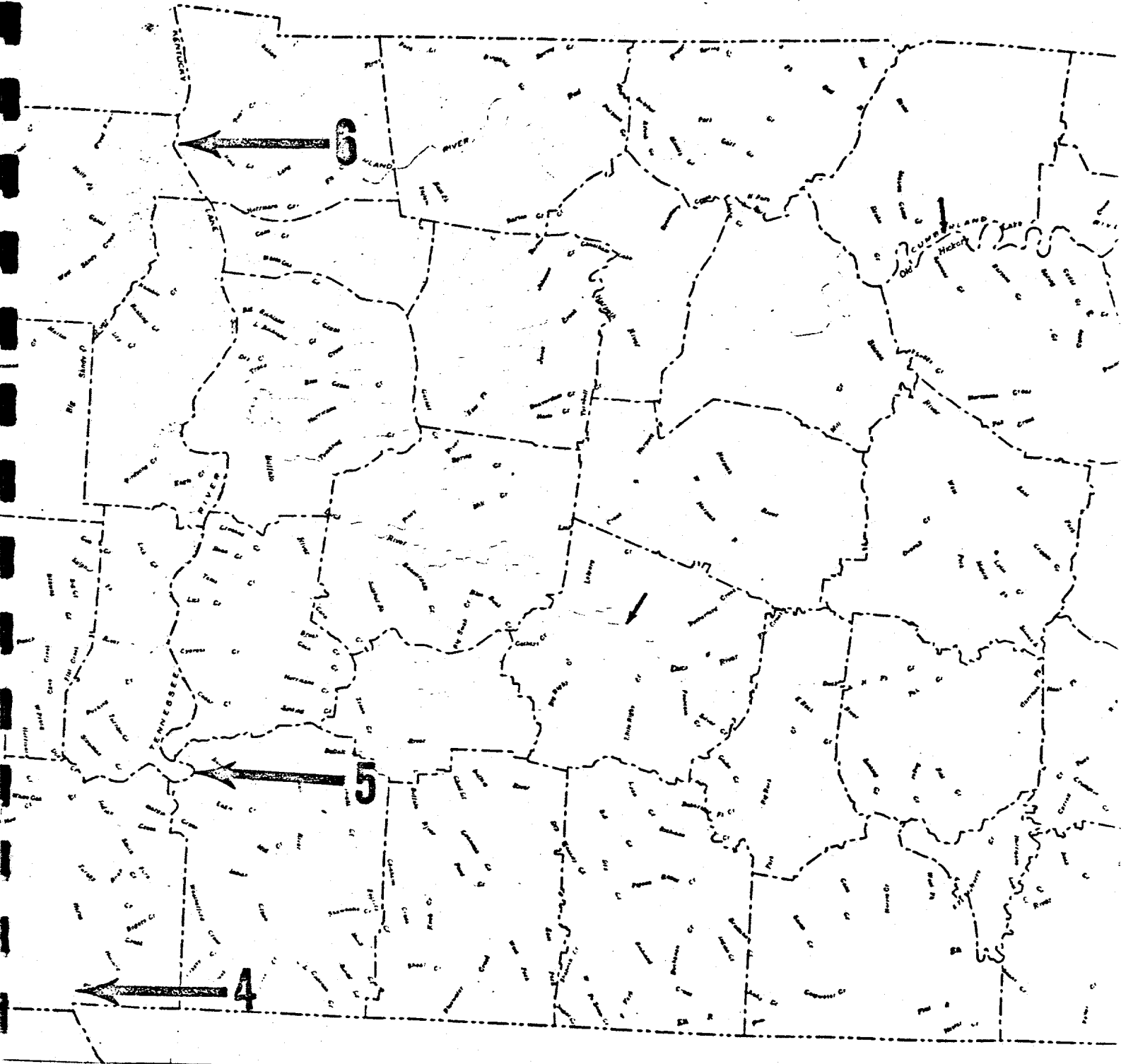
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Department of Health, Education and Welfare.

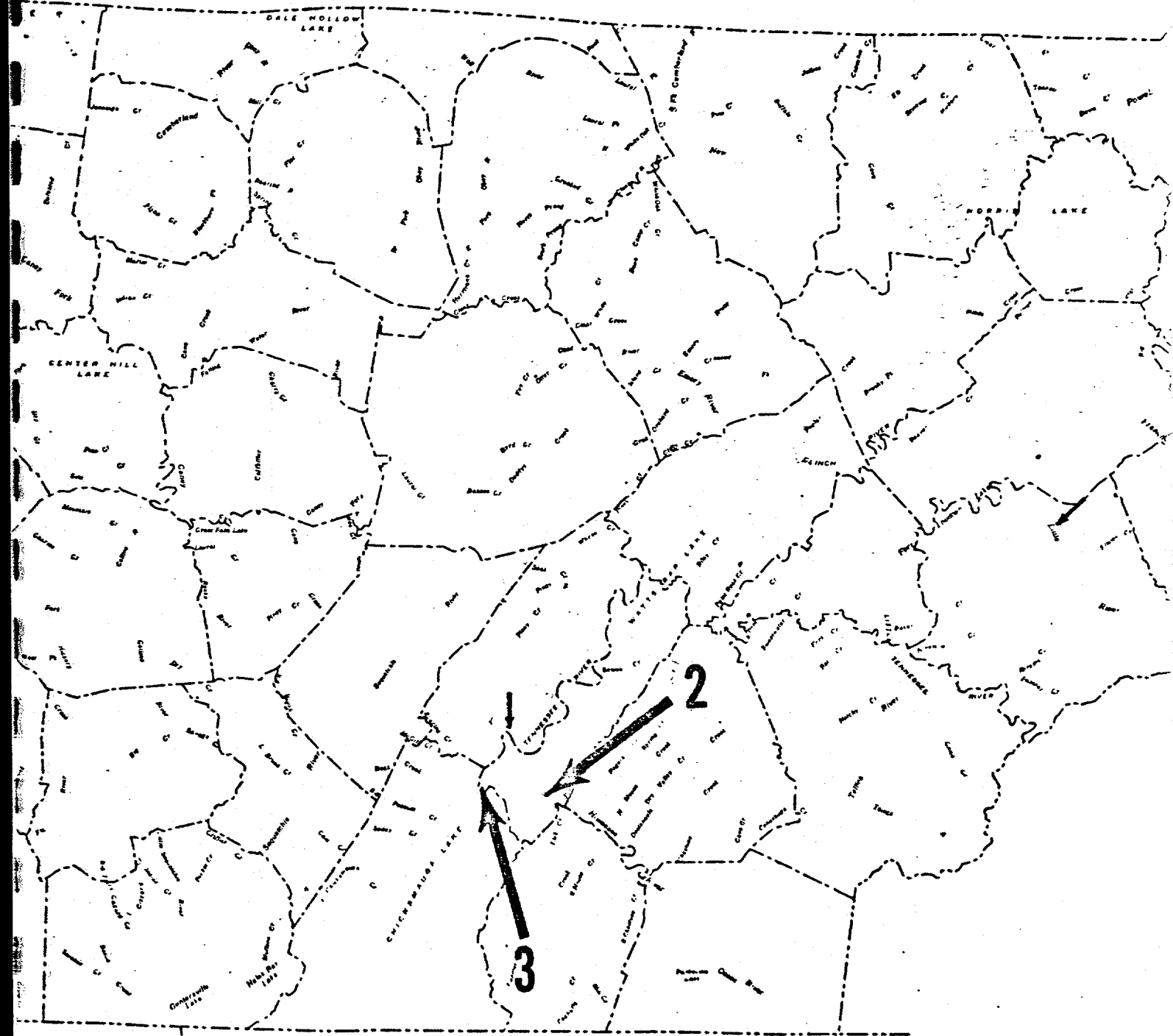
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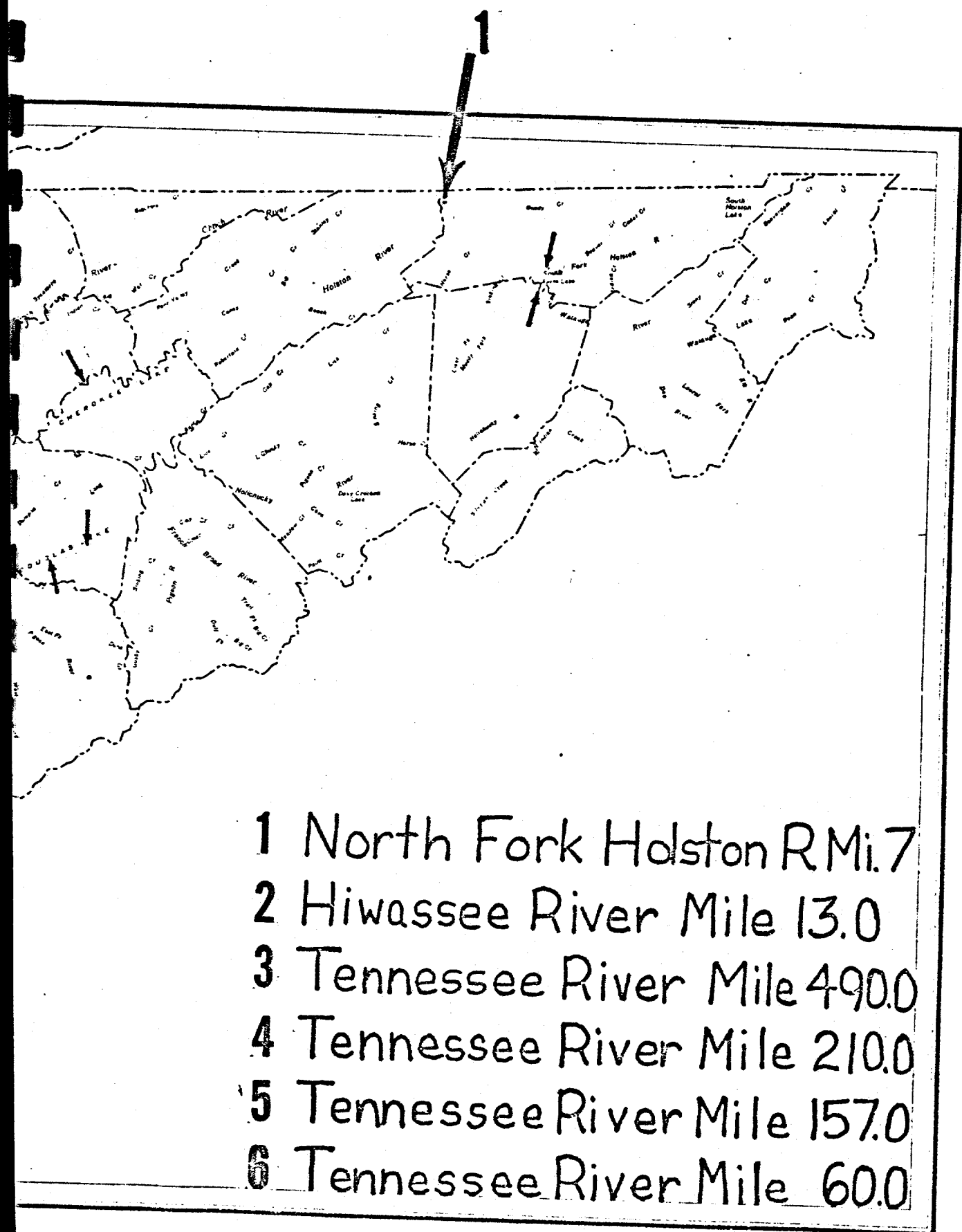
MINIMATA: Words and Photographs, W. Eugene Smith and Aileen  
M. Smith, 1975.

# MERCURY MONI



# DRING STATIONS





The averages provide an important function, however, they fail to display peak values that could be meaningful in showing trends, and that the problem could be potentially more serious than the means have indicated. Results for 1973 are represented by the open bar, 1974 by the cross-hatched bar, and 1975 by the solid black bar.

The vertical column to the left of the graph represents the wet weight concentration of mercury expressed in ppm.

The heavy horizontal line at the 0.5 ppm level indicates the Food and Drug Administration's Maximum Permissible Limit for human consumption.

In instances where the vertical bars are absent, that particular species of fish was not included in that year's sample.

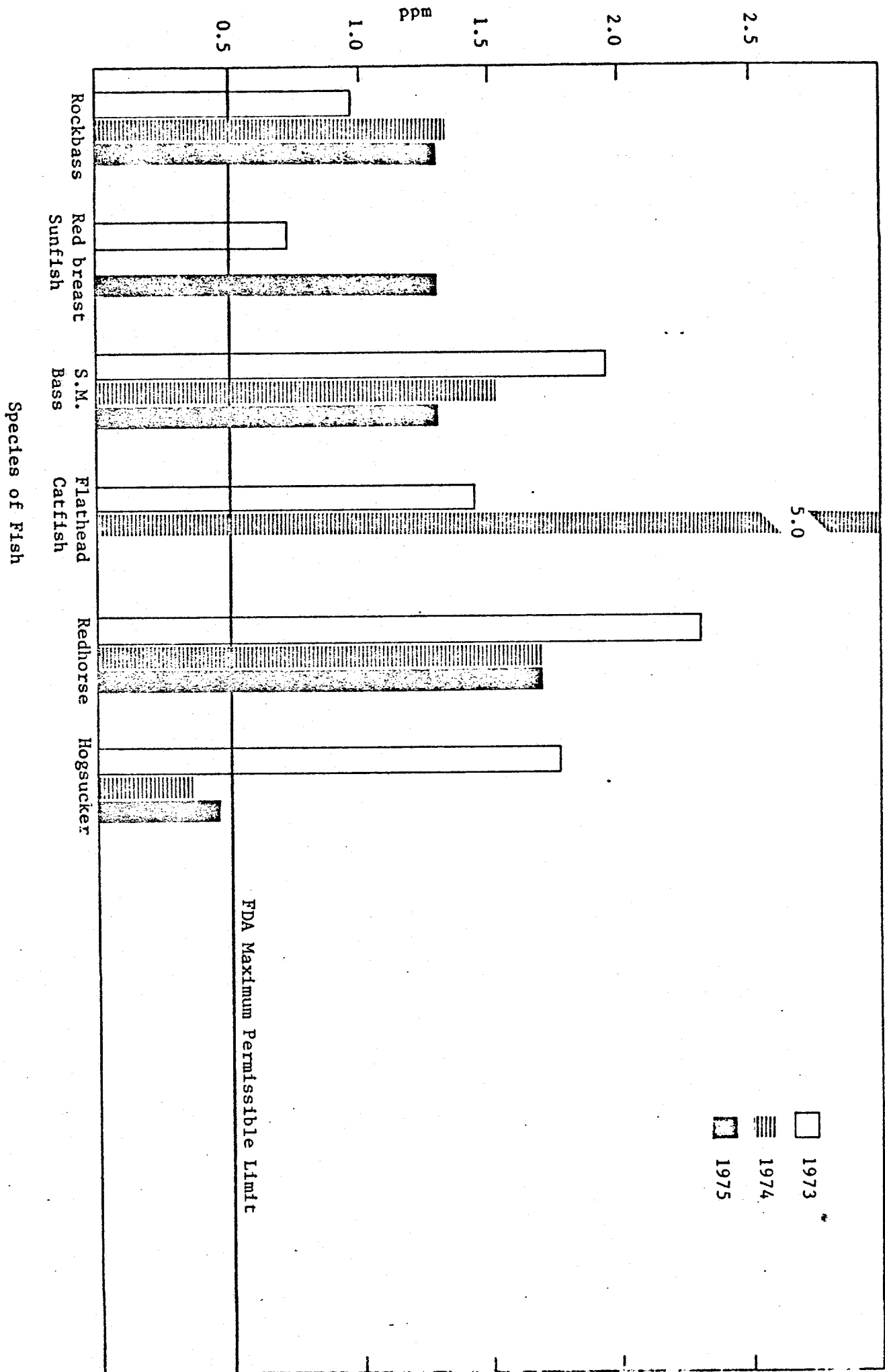
The species of fish appears at the bottom of the graph under the vertical bars for a given year.

#### GRAPH 1 NORTH FORK HOLSTON RIVER

The North Fork of the Holston River has the highest mercury levels of any watercourse in the state. Mean values exceeded maximum permissible limits of 0.5 ppm in 1973, 1974, and 1975. Based on the total specimen collected, muscle tissue of game fish in 1973 exceeded the limit 100% of the time; 88.8% of the time in 1974, and 85.7% in 1975. Liver and kidney tissue exceeded the MPL 100% of the time for all three years.

Smallmouth Bass had the highest concentration of any of the game fish reaching a level of 2.6 ppm, or over 5 times the MPL. This was exceeded

Graph I  
Mercury in Muscle of Fish from the North Fork of the Holston River, Ml. 7.0  
Based on Mean Values



Graph Ia  
Mercury in Muscle of Fish from the North Fork of the Holston River, MI. 7.0  
Based on Maximum Values

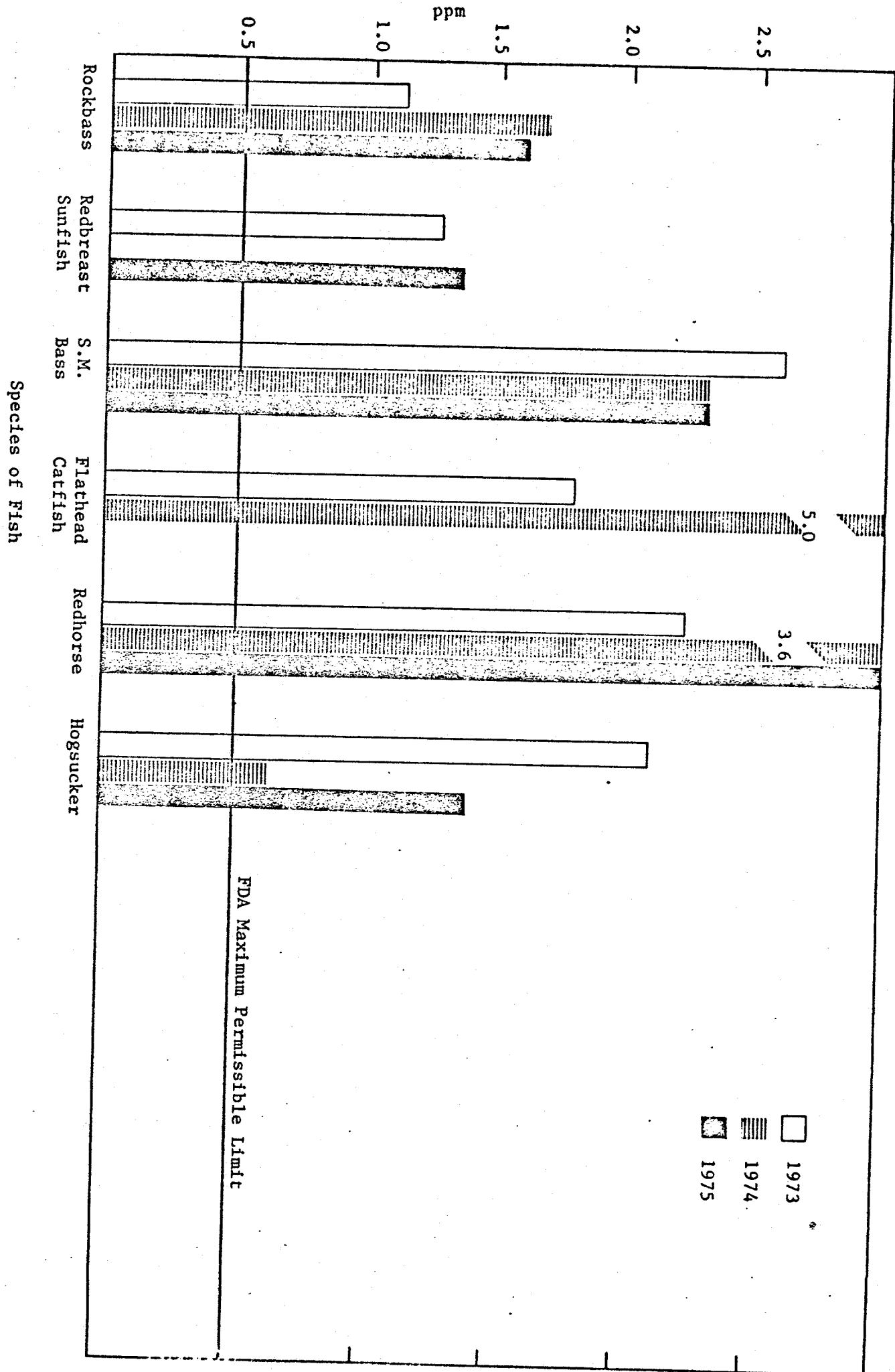


TABLE 1

Table 1 is a condensed summary of the results from the North Holston. This type table was prepared only for this station. The species and number of fish collected in 1973, 1974, and 1975 are shown. mean values have been calculated for each species, and the total number of fish that exceed each level for each species for each of the three years.

TABLE 1  
RESULTS OF FISH ANALYSIS BY SPECIES FROM NORTH FORK HOLSTON RIVER, MILE 7.0

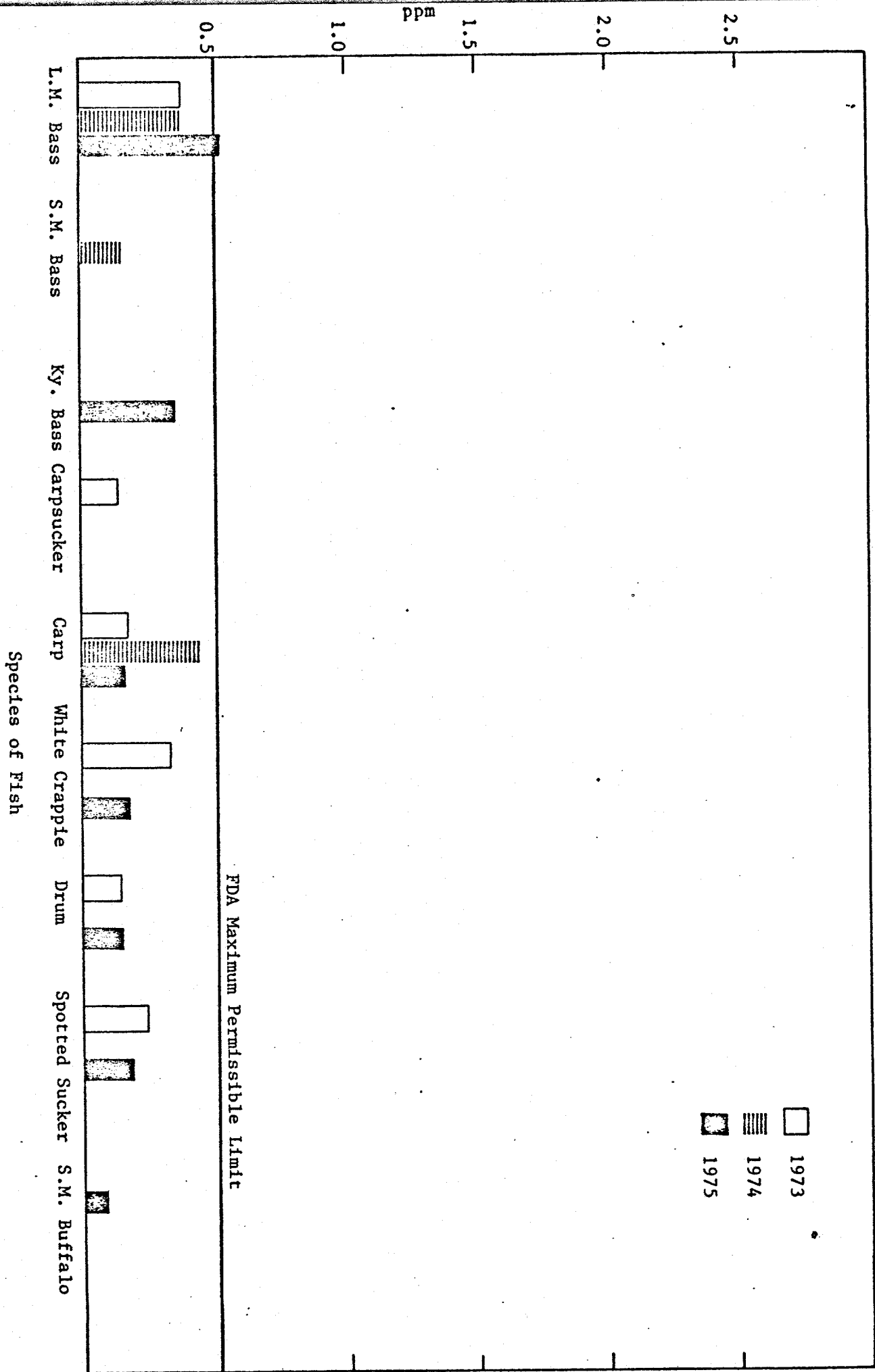
Species	No. Fish Collected			Mean P.P.m.	No. Above Levels									
	1973	1974	1975		0.5	1.0	1.5	2.0	2.5	3.0				
Rock Bass	9	10	4	0.99 0.95 1.3	9 10 4	3 8 3	2 4 1	0 3 0	0 0 0	0 0 0				
Smallmouth Bass	26	8	8	1.94 1.5 1.3	26 6 6	25 5 6	21 3 4	7 3 1	3 0 0	0 0 0				
Redbreast Sunfish	13	4	3	0.72 0.73 1.3	8 3 3	2 0 2	0 0 0	0 0 0	0 0 0	0 0 0				
Redhorse	5	6	5	2.003 1.7 1.7	3 5 5	3 4 3	2 4 3	2 2 2	1 1 1	0 0 0				
Hogsuckers	9	7	5	1.8 0.17 0.47	9 4 1	5 2 1	3 0 0	2 0 0	0 0 0	0 0 0				
Channel Cat	2	1	-	1.4 5.00 -	2 1 -	2 1 -	1 1 -	0 1 -	0 1 -	0 1 -				
Flathead Cat	2	1	-	1.4 5.00 -	2 1 -	2 1 -	1 1 -	0 1 -	0 1 -	0 1 -				
Quillback	2	-	-	2.25 - -	2 - -	2 - -	2 - -	1 - -	1 - -	1 - -				

## GRAPH II AND II (a)

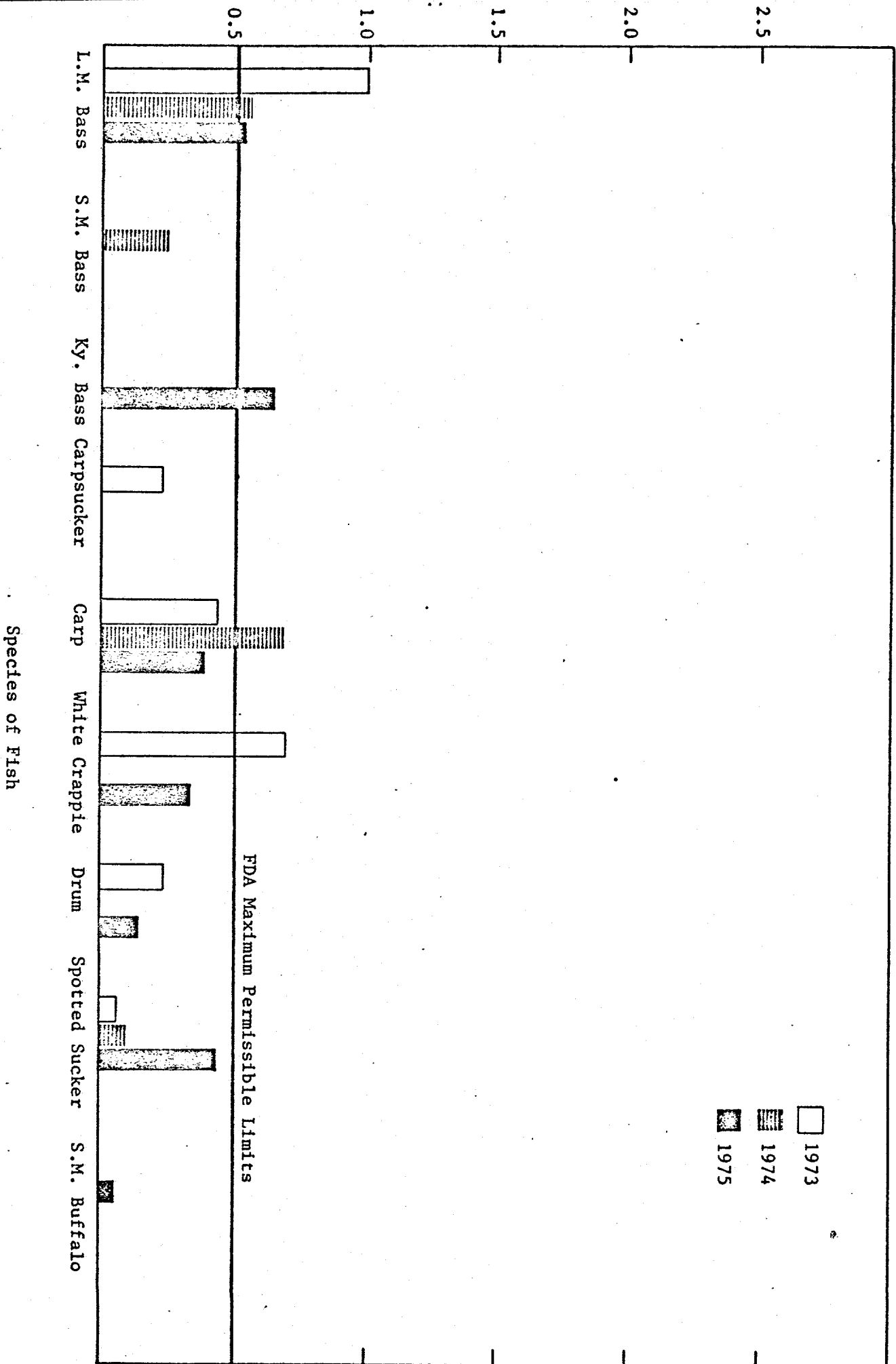
## HIWASSEE RIVER, MILE 13

Mean values for largemouth bass in 1975 were the only species exceeding the MPL. Carp in 1974 reached 0.45 ppm. Smallmouth bass, carpsucker, drum, and smallmouth buffalo were only slightly above what one would expect to be background levels. The MPL values were exceeded by largemouth bass in 1973, 1974, and 1975. Carp was the only species exceeding 0.5 ppm of the rough fish. This was in 1974. White crappie in 1973 and Kentucky bass in 1975 exceeded the MPL.

Graph II  
Mercury in Muscle of Fish from the Hwassee River, MI. 13.0  
Based on Mean Values



Graph IIa  
Mercury in Muscle of Fish from the Hiwassee River Mt. 13.0  
Based on Maximum Values

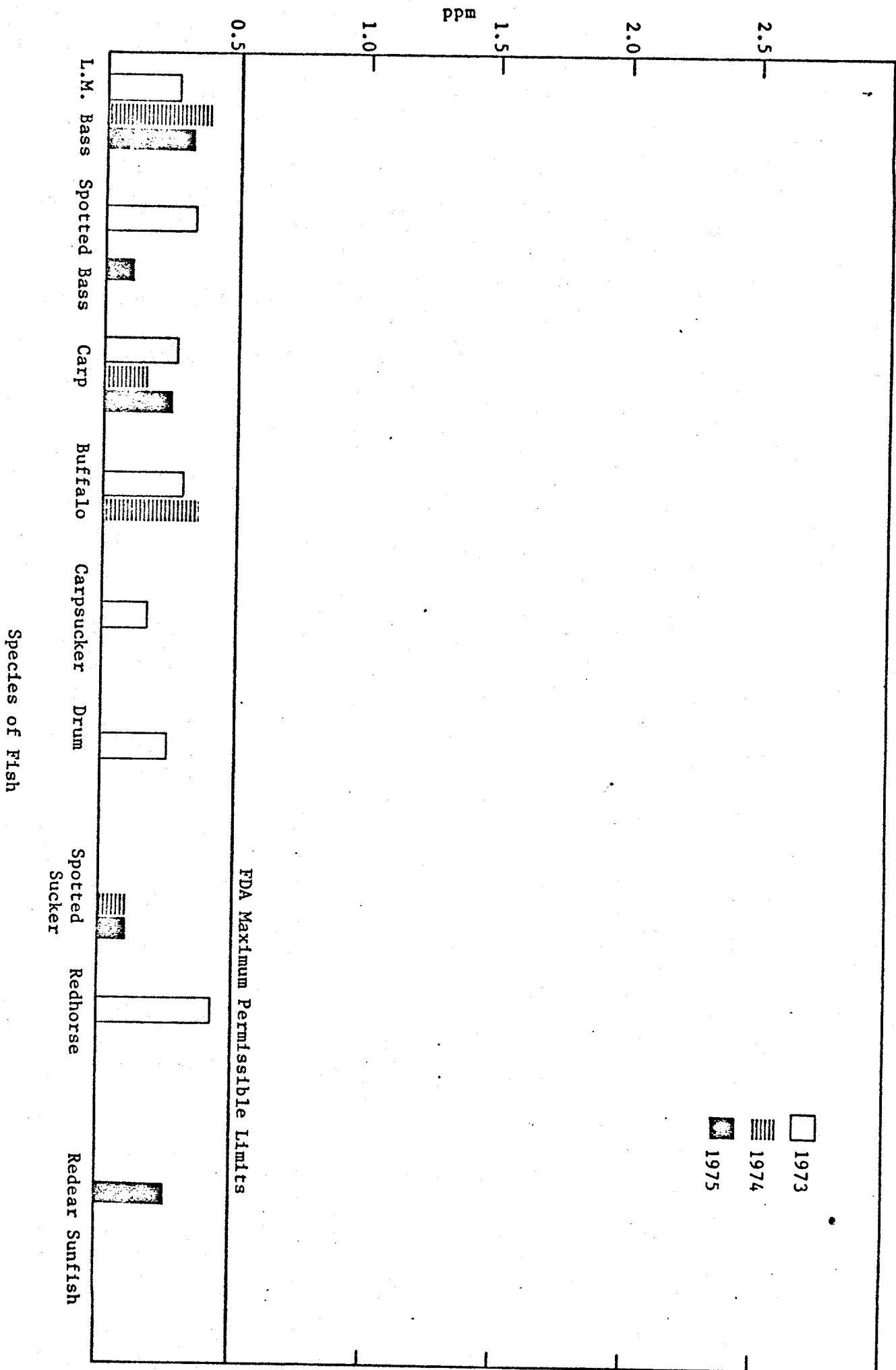


## GRAPH III AND III (a)

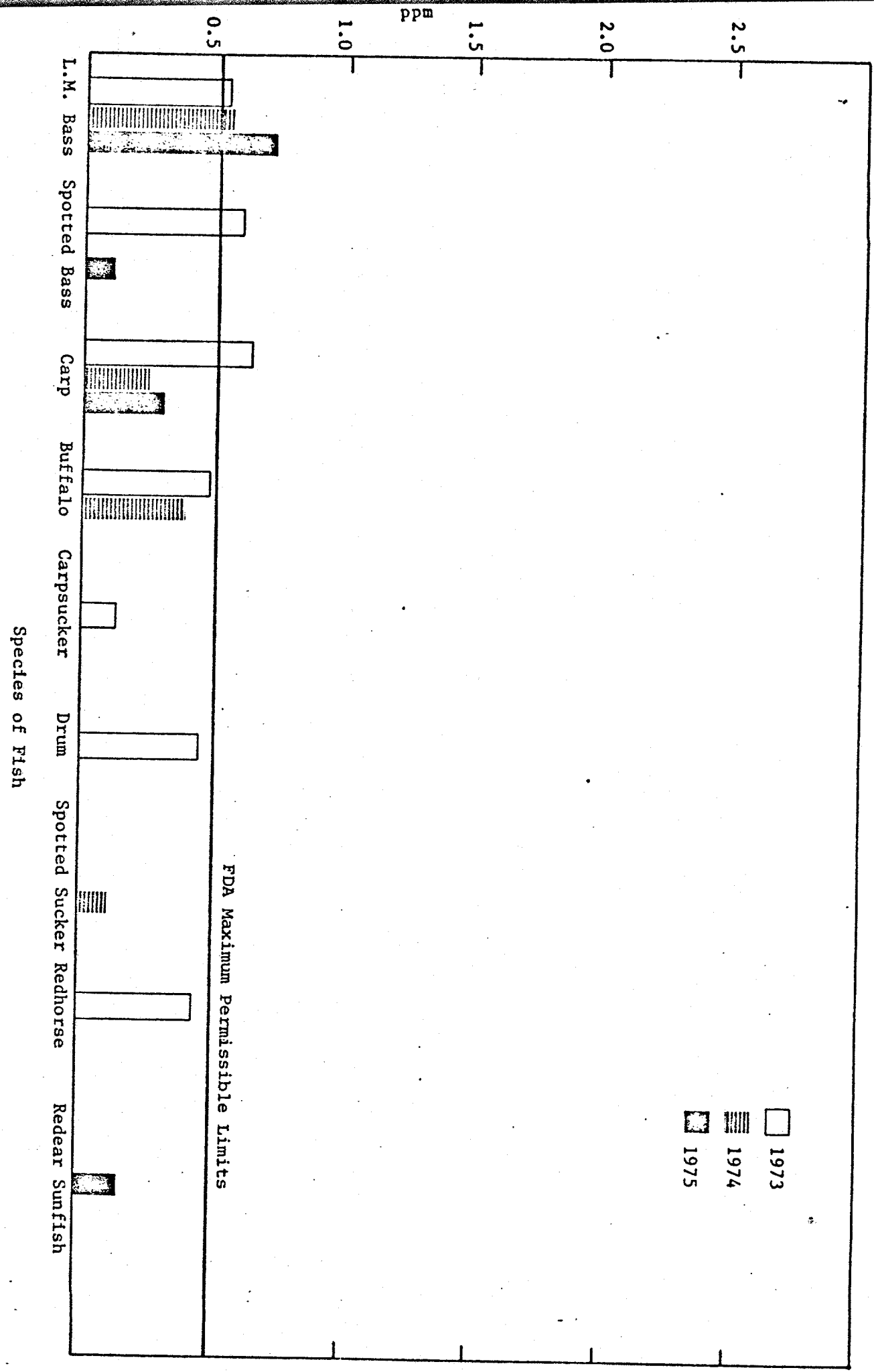
## TENNESSEE RIVER MILE 490

This station is in close proximity to the Hiwassee River. Mean values for the two stations are somewhat similar. No mean value for any species of fish exceeded the MPL. Redhorse had the highest level in 1973, largemouth bass in 1974 and also in 1975. Maximum values showed the largemouth bass to be only 0.21 ppm above the MPL. Buffalo were next highest. The carp in 1973 and the largemouth bass in 1975 were the only species that exceeded the MPL.

Graph III  
Mercury in Muscle of Fish from the Tennessee River, Ml. 490  
Based on Mean Values



Graph IIIa  
 Mercury in Muscle of Fish from Tennessee River, Mt. 490  
 Based on Maximum Values

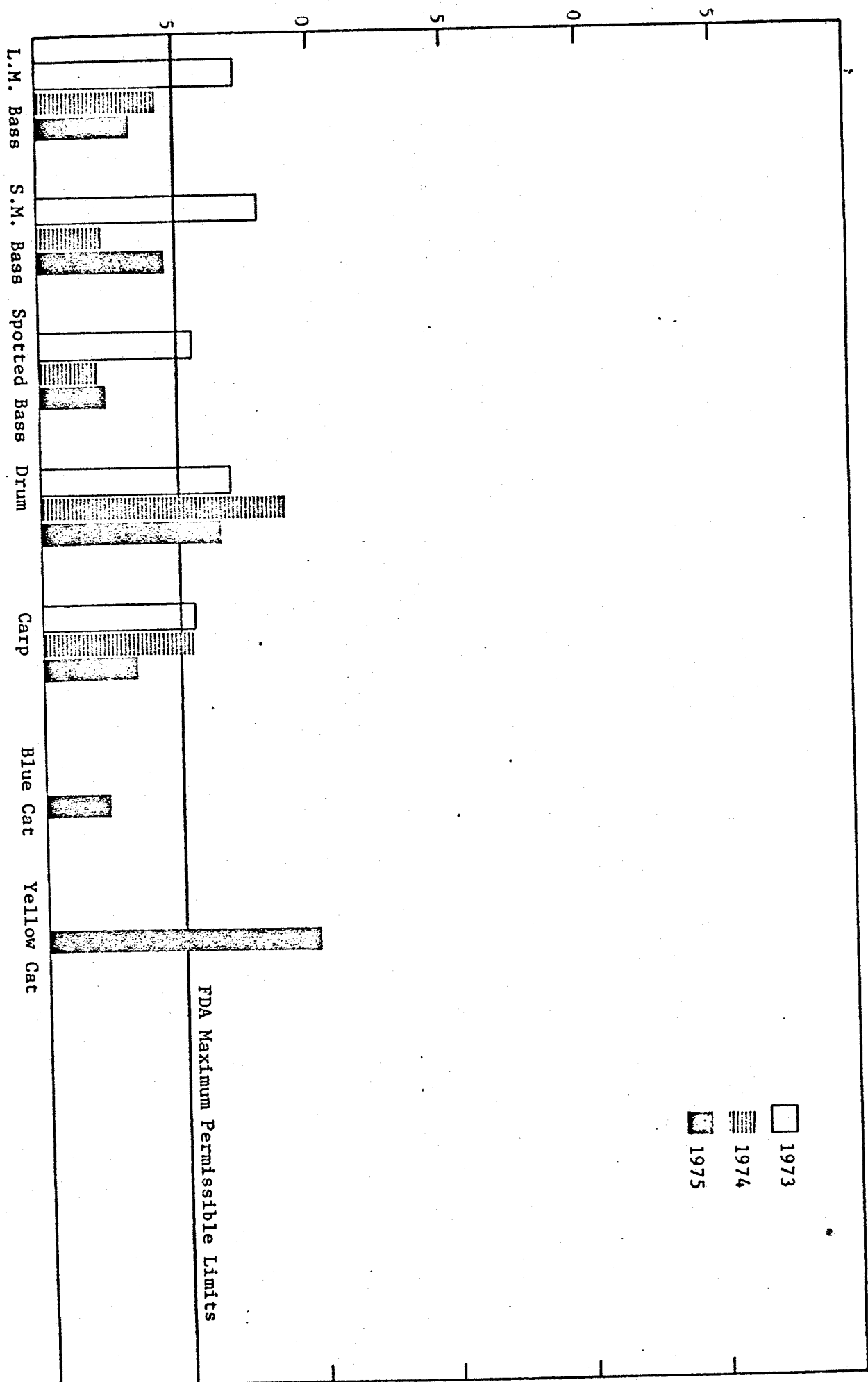


GRAPH IV AND IV (a)

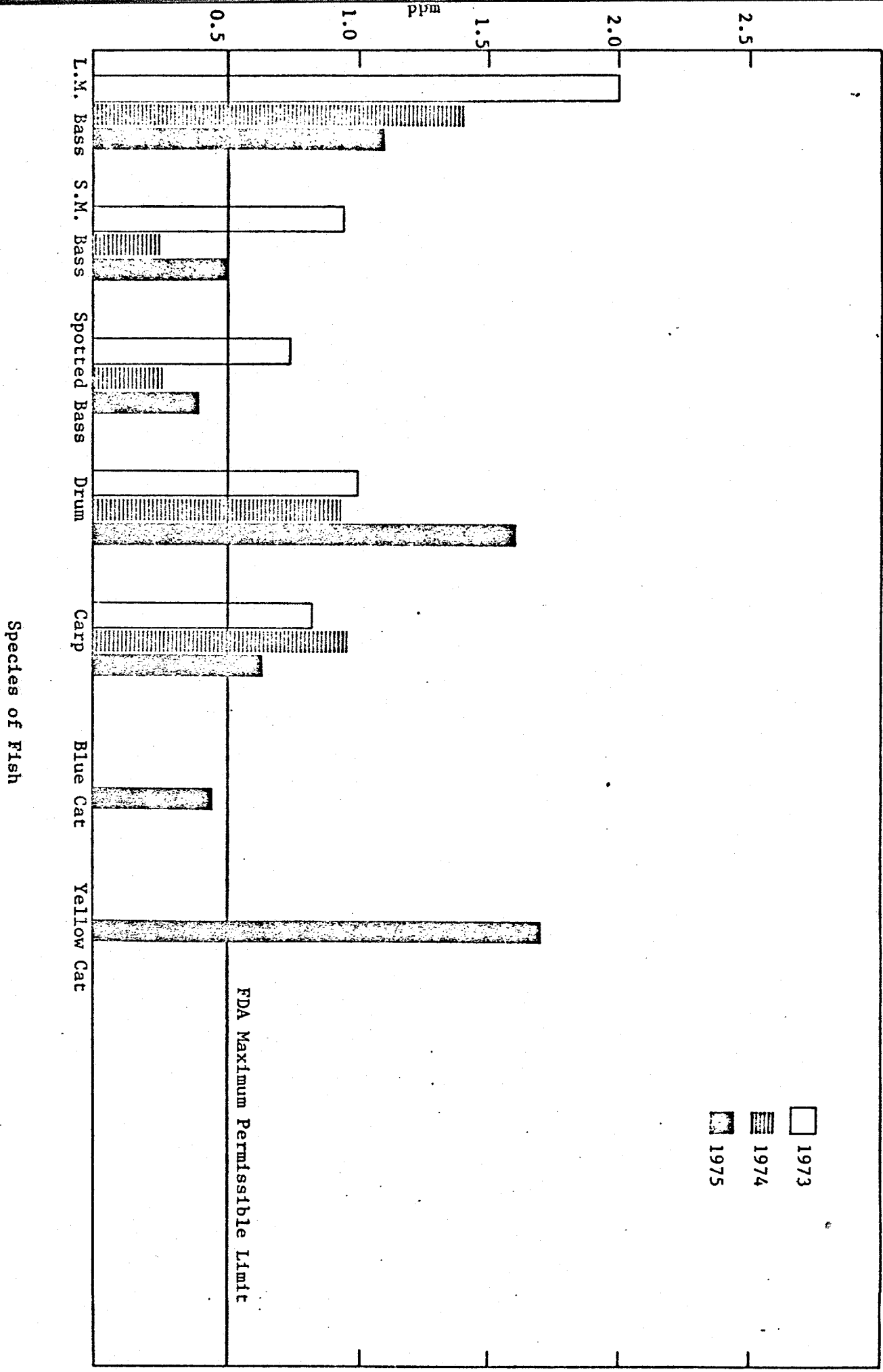
TENNESSEE RIVER MILE 210

This station is closest to the Diamond Shamrock Company. It, along with other segments of the Tennessee River in Alabama were closed to fishing because of the mercury levels in 1970, but, has since been reopened. Based on mean values, blue cat was the only species contained in the 1973 samples that was below the MPL. Smallmouth bass were 0.1 ppm higher than largemouth bass which exceeded the MPL by 0.22 ppm. Largemouth bass in 1974 had maximum values 4 times higher than the MPL. Carp and drum were almost twice the limit. In 1975 drum and yellow cat exceeded the maximum limit over 3 times.

Graph IV  
Mercury in Muscle Tissue of Fish from Tennessee River Ml. 210  
Based on Mean Values



Graph IVa  
 Mercury from Muscle Tissue of Fish from Tennessee River Ml. 210  
 Based on Maximum Values



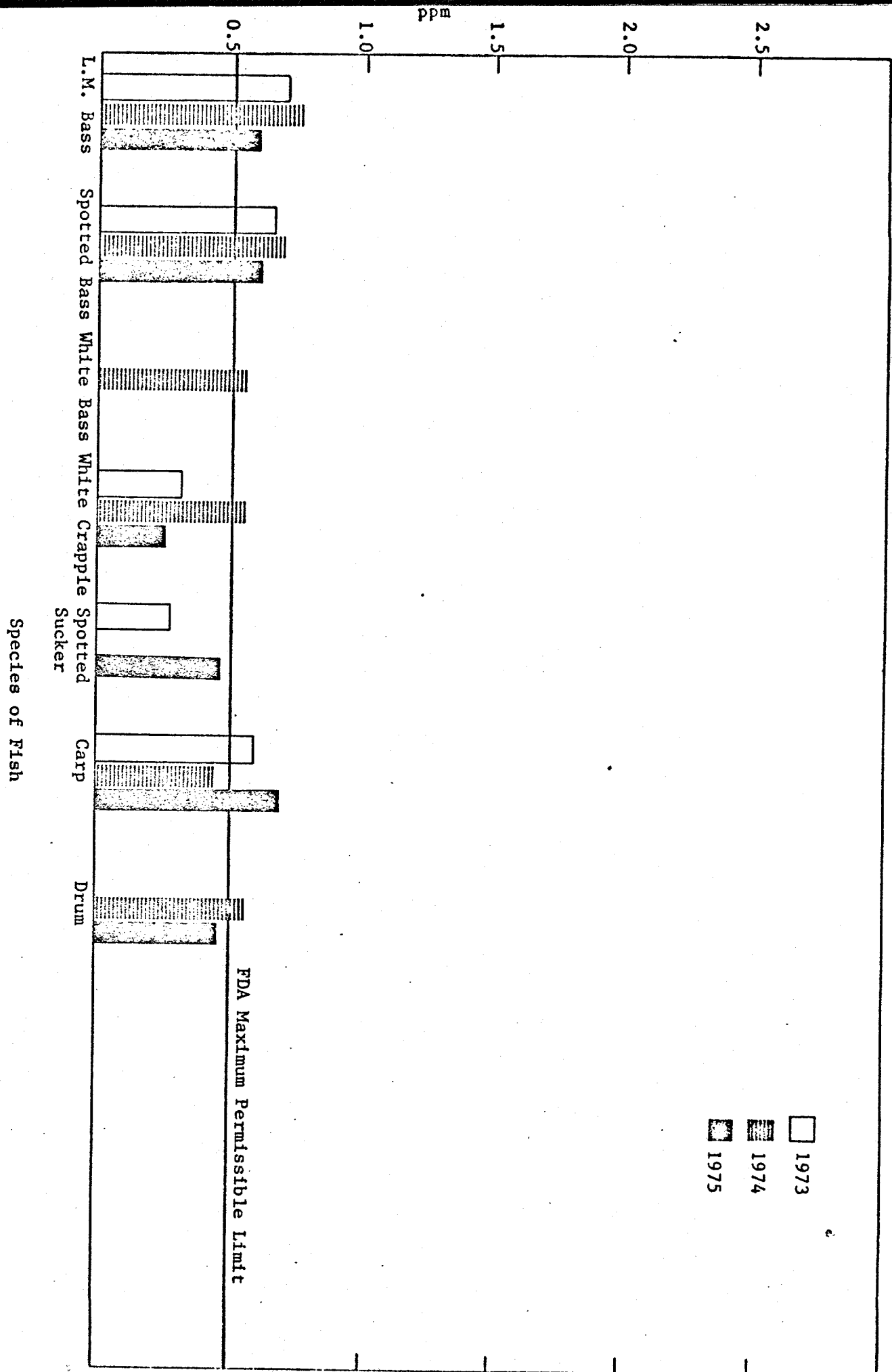
## GRAPH V AND V (a)

## TENNESSEE RIVER MILE 157

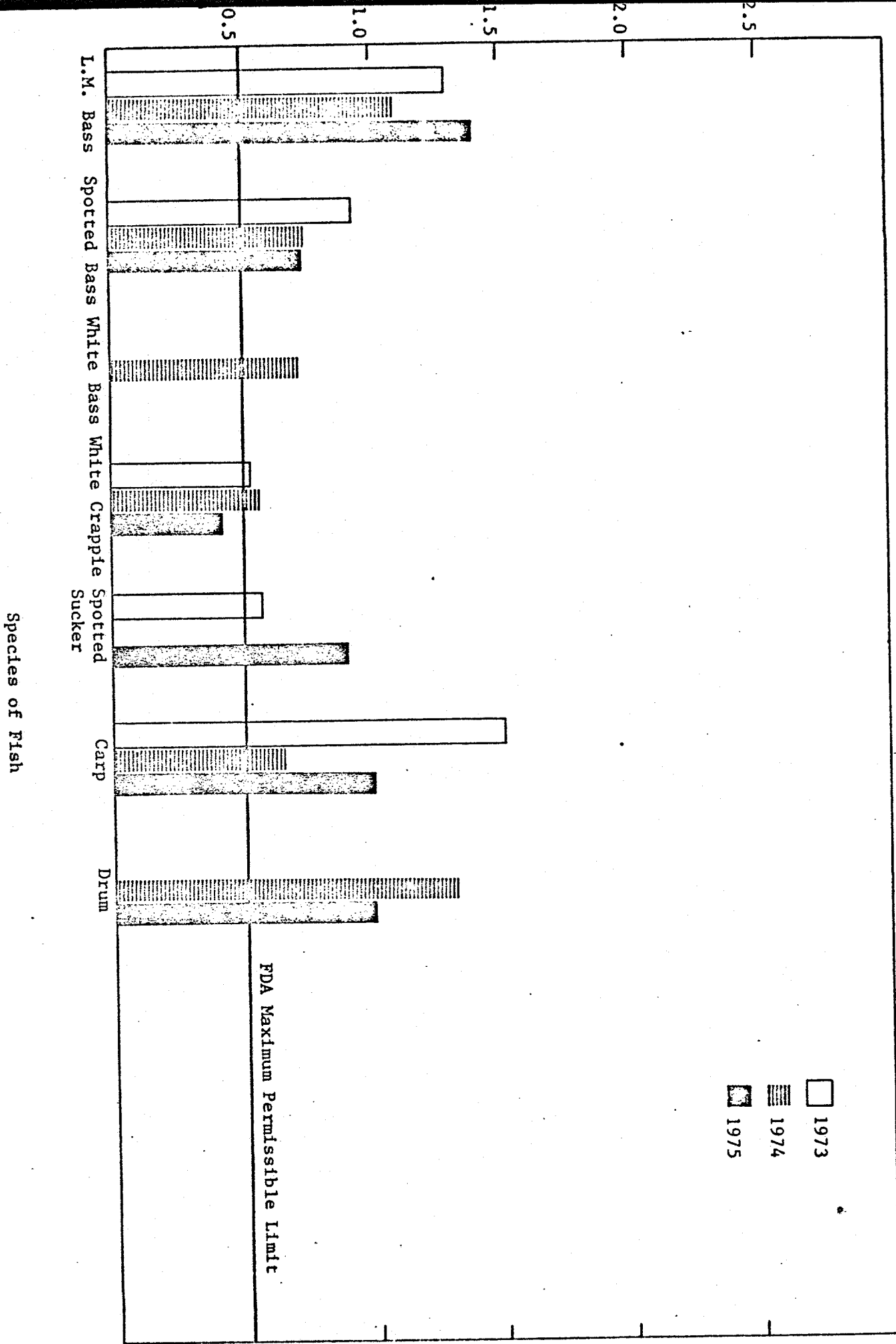
This station is located in the upper reaches of Kentucky Reservoir. At this location it is a main channel reservoir and more nearly approaches a true river condition than the other main stem stations on the Tennessee. It is below the Diamond Shamrock Company and the Tennessee River Pulp and Paper Mill. Plankton samples for mercury analysis have been collected here in conjunction with part of the fish samples. In general, the values obtained from Plankton determinations have coincided with those of the fish, having been as high or higher.

Mean values from fish analysis in 1973 exceeded the MPL in all species sampled except white crappie and spotted suckers. Maximum values surpassed the MPL for all species collected in 1973 and 1974. White crappie was the only species in 1975 that had maximum values less than the MPL. Largemouth bass were more than double the permissible limits in 1973, 1974, and 1975. In 1973, carp maximum values were three times the MPL.

Mercury in Muscle Tissue of Fish from Tennessee River Ml. 157  
Based on Mean Values



Graph Va  
 Mercury in Muscle Tissue of Fish from Tennessee River Mt. 157  
 Based on Maximum Values

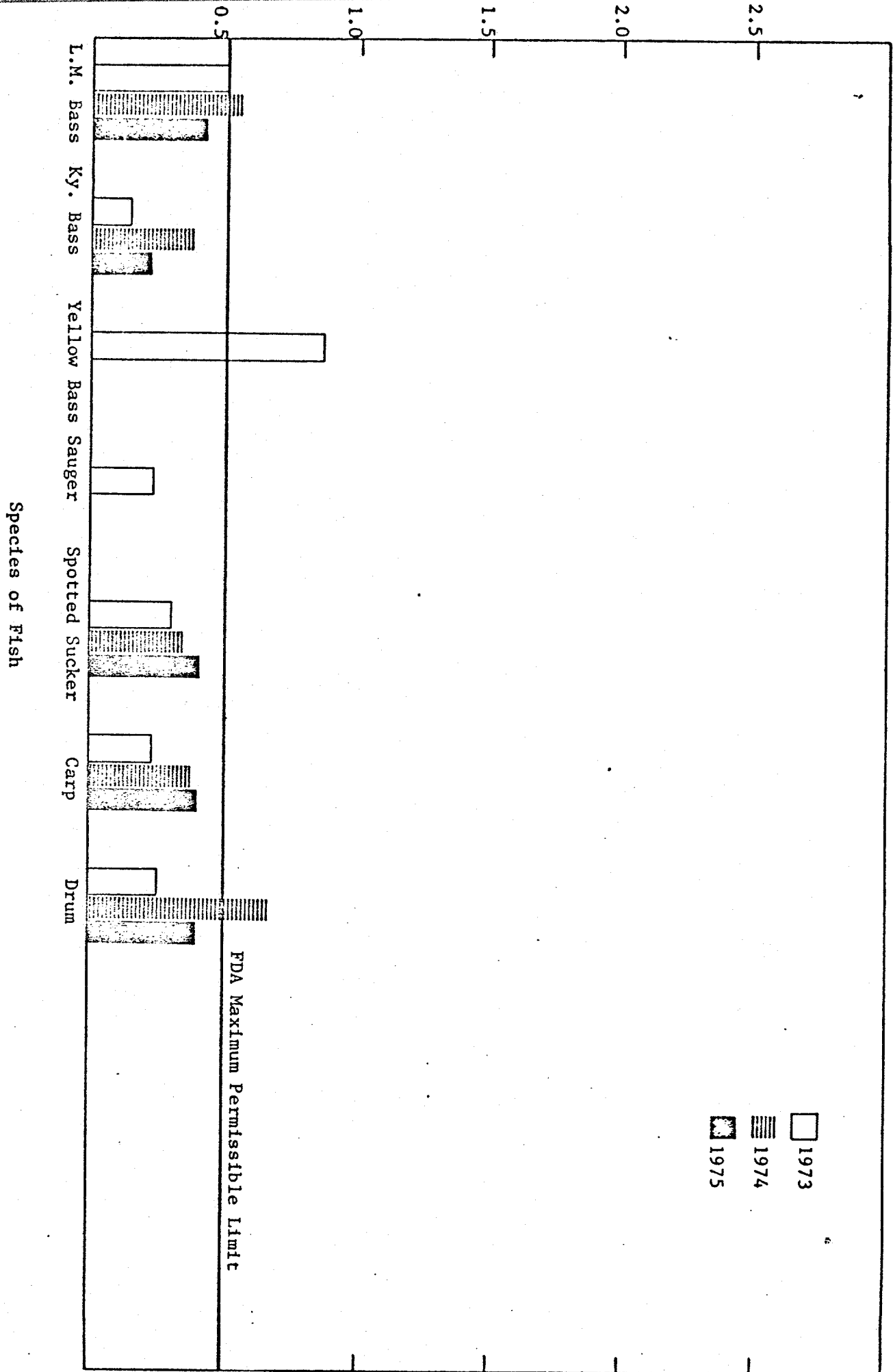


GRAPH VI AND VI (a)

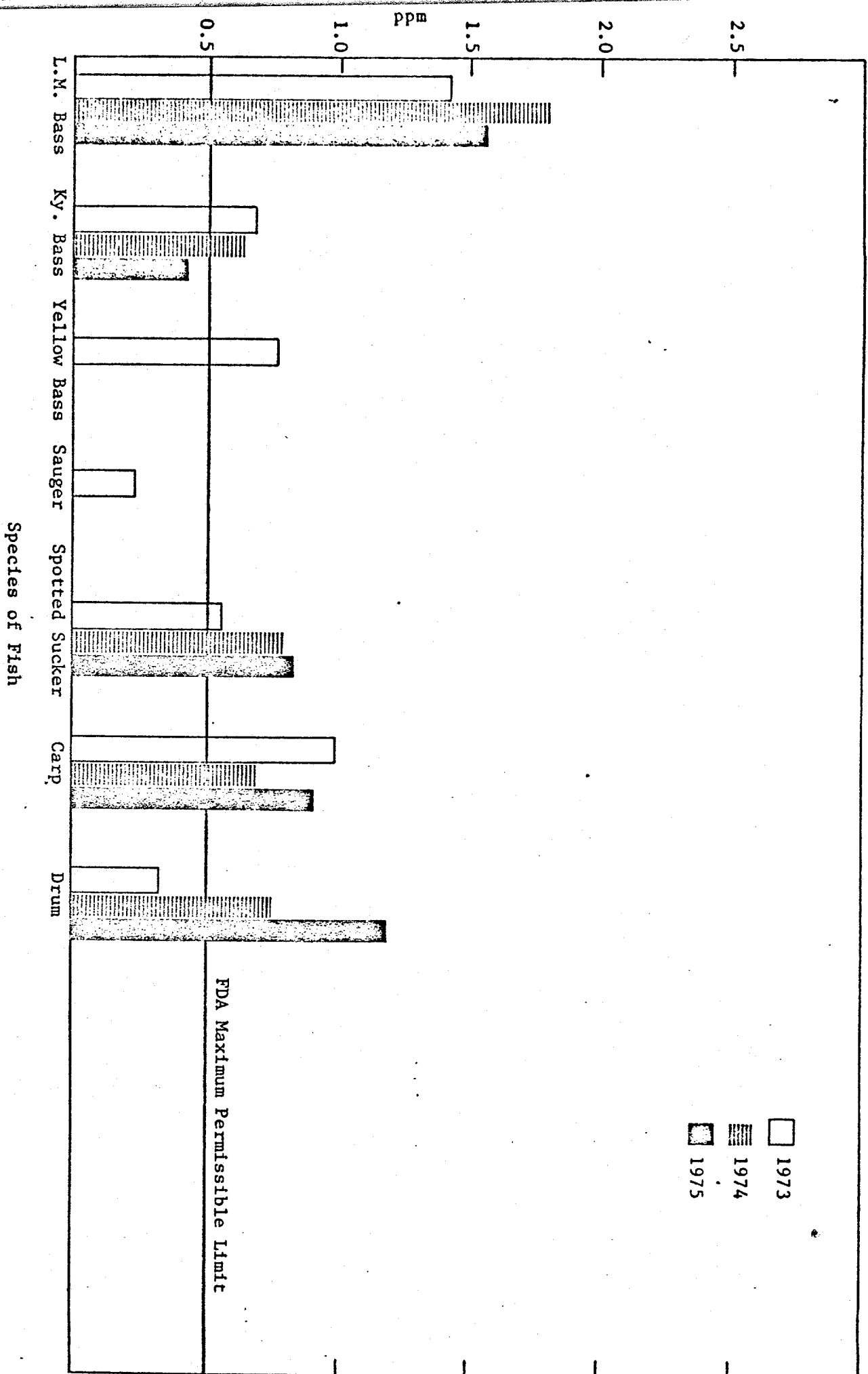
TENNESSEE RIVER MILE 60

Mean values at Mile 60 were a little lower than at Mile 157 for most species. Maximum values for largemouth bass were near three times the MPL for the years 1973, 1974, and 1975. Yellow and Kentucky bass maximums were in excess of permissible limits in 1973. Sauger and drum maximums in 1973 were less than permissible limits. Spotted sucker, carp, and drum exceeded the MPL in 1974 and 1975.

Mercury in Muscle Tissue of Fish from Tennessee River Mt. 60  
Based on Mean Values



Graph Via  
Mercury in Muscle Tissue of Fish from Tennessee River Mt. 60  
Based on Maximum Values



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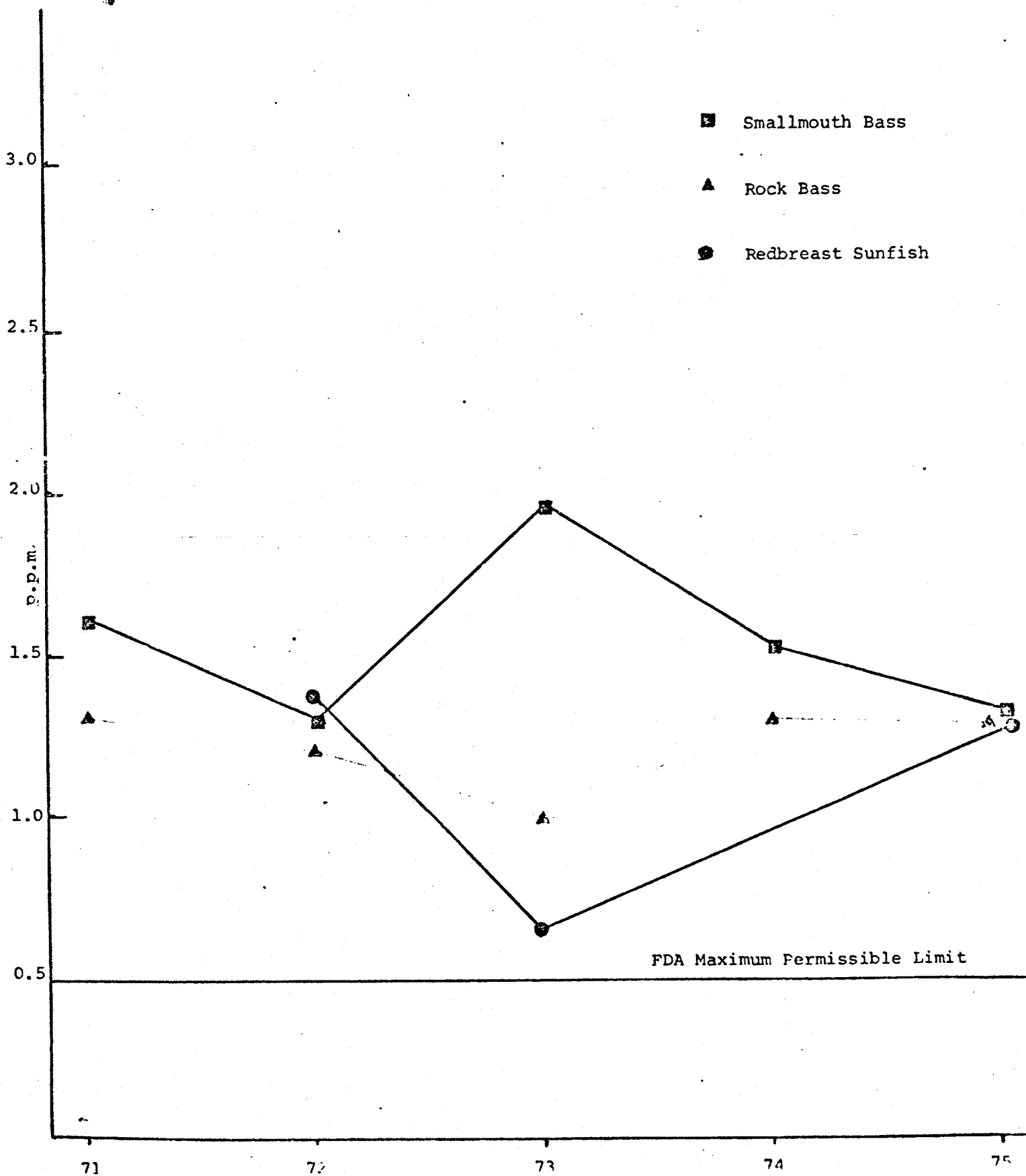
Graphs VII through X (a) show mean and maximum values of the mercury levels for the dominant species at the different stations over a five year period. The different species are color coded, but the color is not consistent for all the stations, since the same species may not be dominant for all stations. However, all color codes are indicated on each graph. The purpose of these graphs is to compare levels at the different years to evaluate trends.

GRAPHS VII AND VII (A)  
NORTH FORK HOLSTON RIVER, MILE 7.0

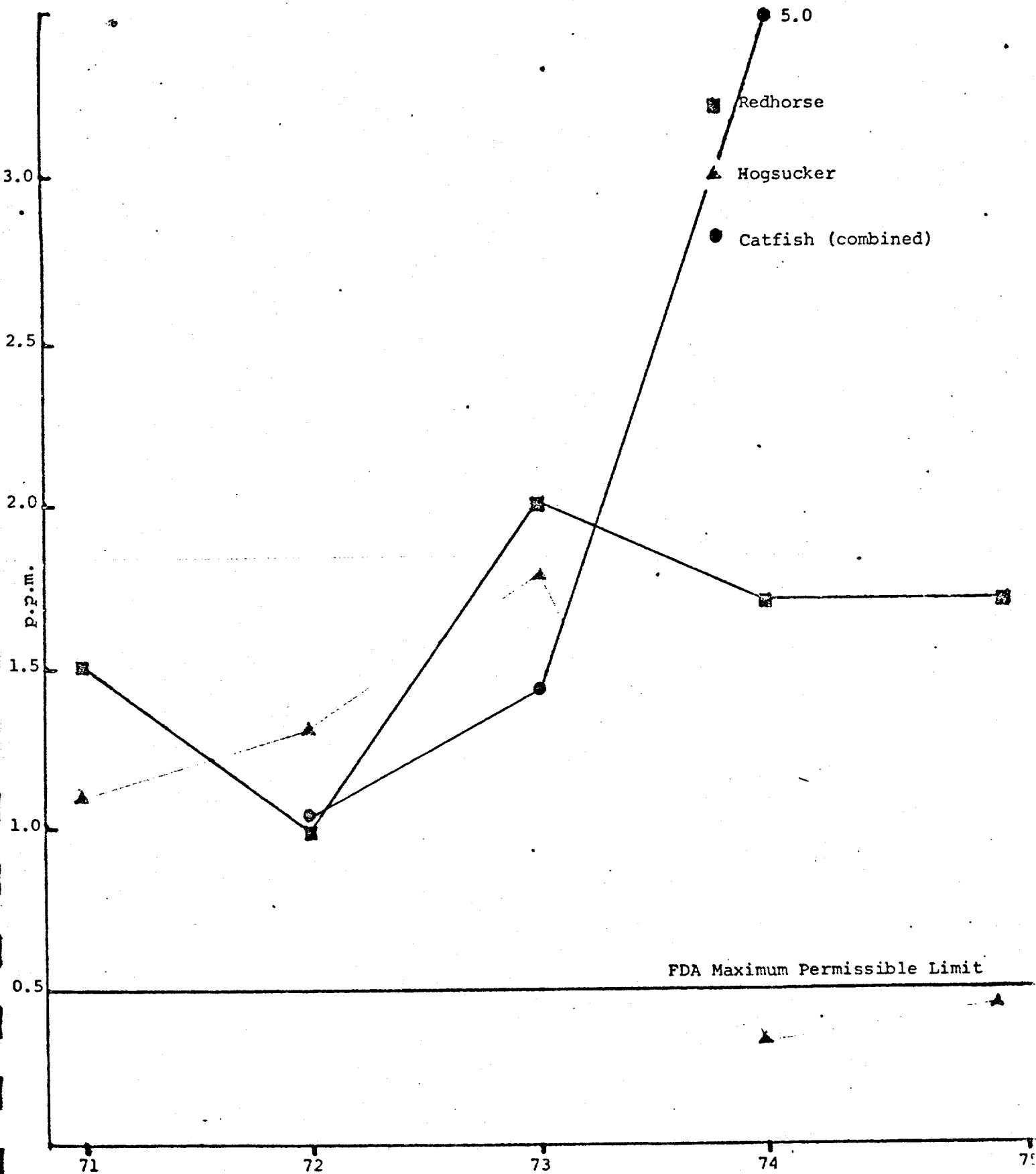
The three dominant species of game fish were the smallmouth bass, rockbass and redbreast sunfish. At no time during the five year period have mean values dropped as low as the MPL. Only 0.3 ppm difference in the species occurred in 1971, with less than 0.2 ppm in 1972, but in 1973 smallmouth bass had a mean value of 0.95 ppm higher than Rockbass, and 1.2 ppm higher than redbreast sunfish. In 1974 means were only 0.2 ppm apart. In 1975 they all had essentially the same level, which was  $2\frac{1}{2}$  times the MPL.

Routh fish showed a greater divergence of concentration with the hog sucker being lowest. It was below the MPL in 1974 and 1975. Catfish reached 5.0 ppm in one specimen.

Graph VII  
Mercury In Muscle of Fish  
North Fork of the Holston River, Mi. 7.0  
Game Fish - Mean Values



Graph VIIa  
Mercury in Muscle of Fish  
North Fork of the Holston River, Mi. 7.0  
Rough Fish, Mean Values



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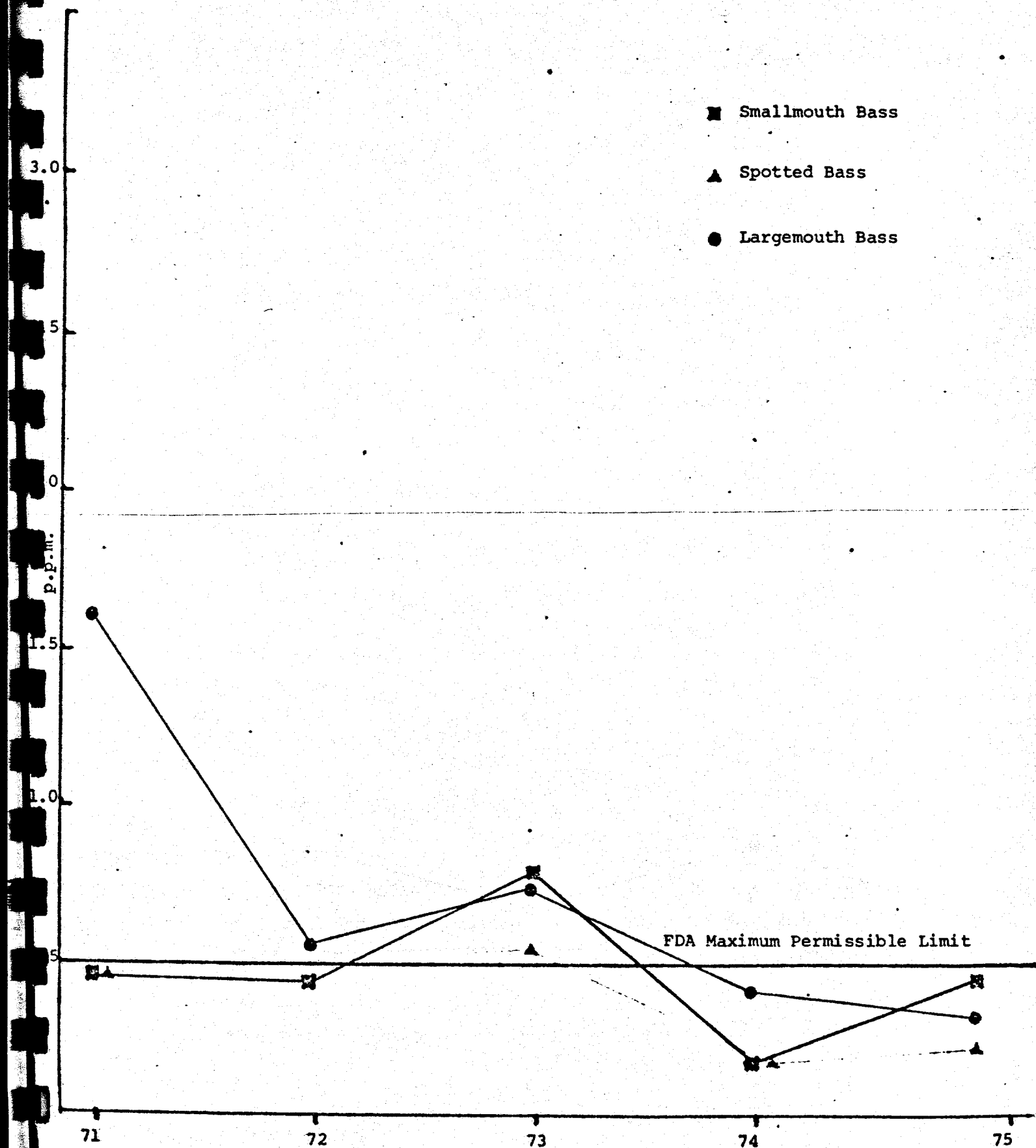
GRAPH VIII

TENNESSEE RIVER MILE 210

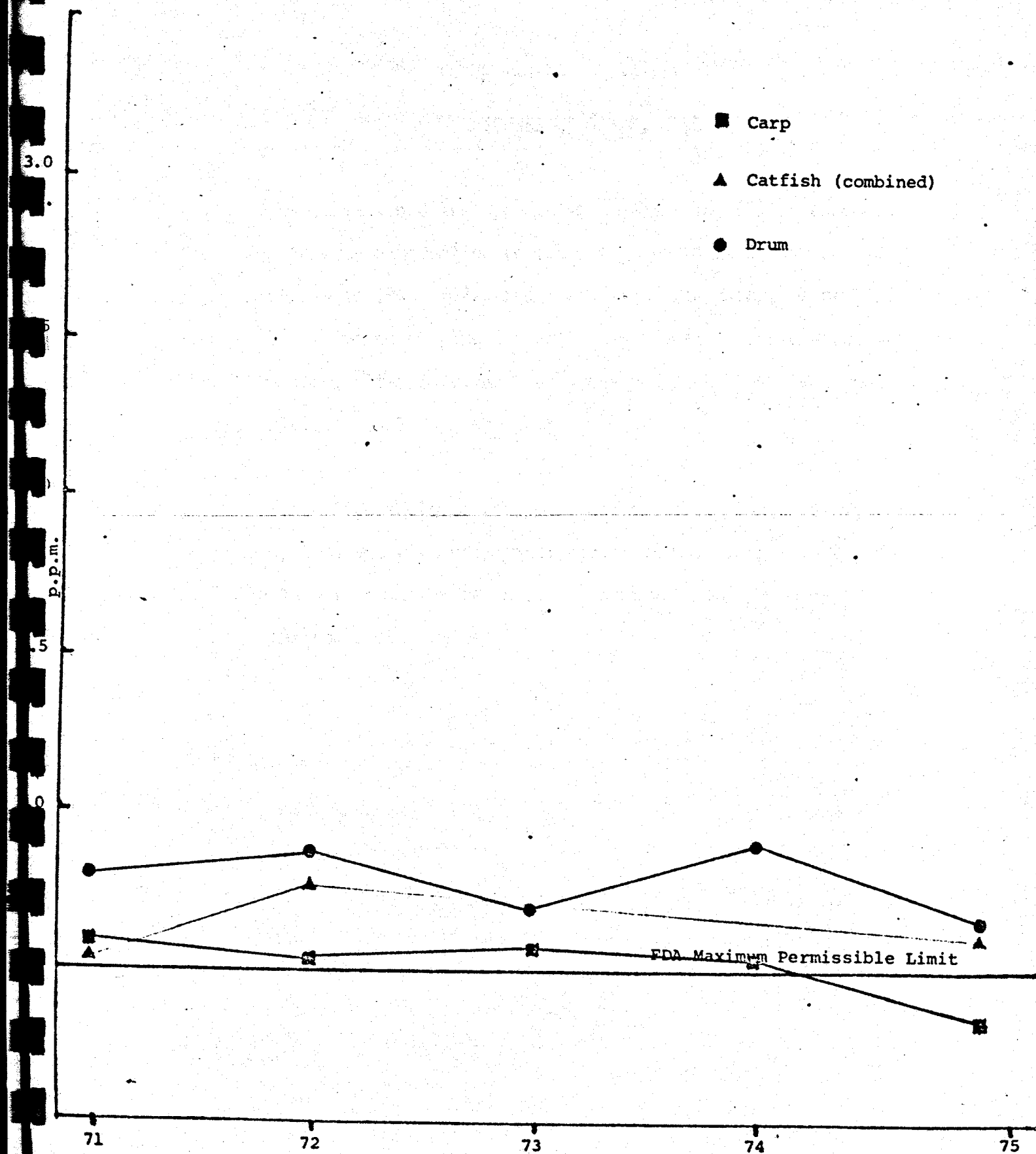
Largemouth bass in 1971 had a mean value 3 times the MPL, while the smallmouth and spotted bass were 0.45 ppm, or just under the MPL. The largemouth were down in 1972 with the smallmouth and spotted bass remaining essentially constant. They were up approximately 0.3 ppm in 1973, but down again in 1974 and 1975.

Rough fish showed some fluctuation, but remained essentially constant for the five year period.

Graph VIII  
Mercury in Muscle of Fish  
Tennessee River, Mi. 210  
Game Fish, Mean Values



Graph VIIIa  
Mercury in Muscle of Fish  
Tennessee River, Mi. 210  
Rough Fish, Mean Values



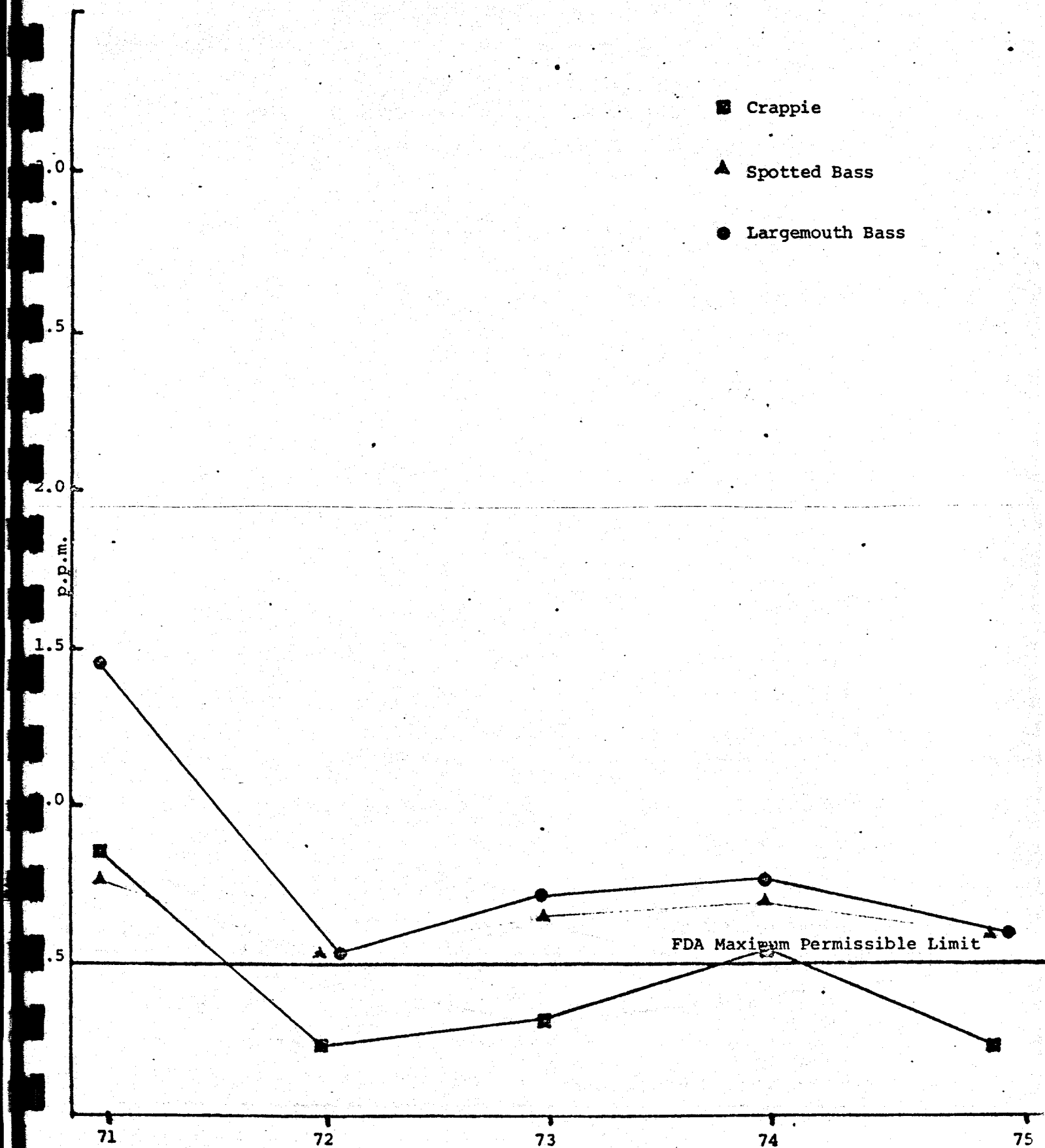
## GRAPH IX AND IX (a)

## TENNESSEE RIVER, MILE 157

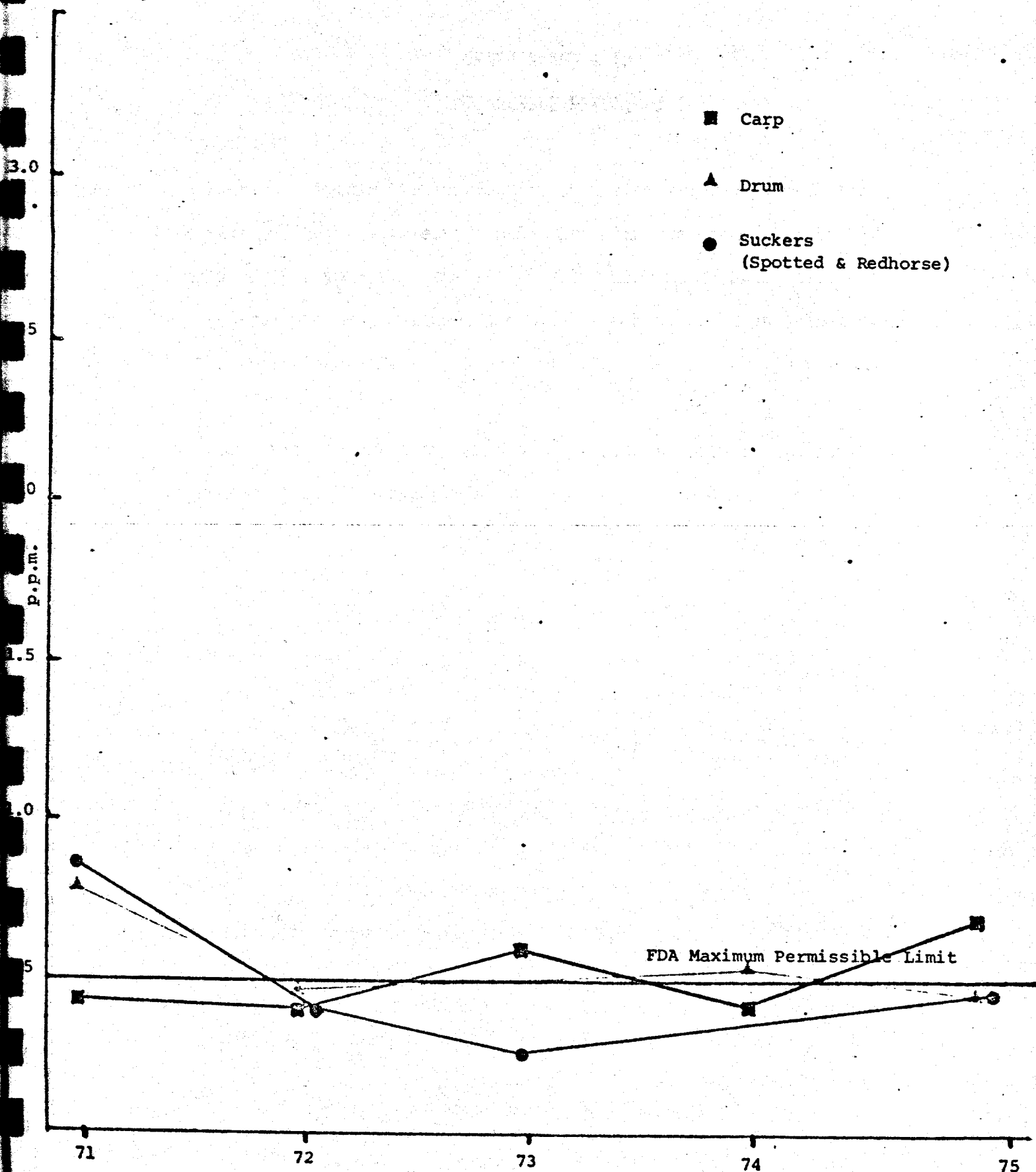
Largemouth bass had the highest mean values in 1971 or about 3 times the MPL with a reduction to 0.5 ppm level in 1972, and only a slight increase in 1973, 1974, and 1975. With the exception of 1971 spotted bass followed an almost identical pattern. Crappie were lower at all instances after 1971, and below the MPL except for 1974 when it reached a level of 0.05 ppm above it.

The rough fish included carp drum and suckers. Their levels remained essentially constant with only minor fluctuations. Carp were 0.3 ppm higher in 1975 than they were in 1971. Drum were only slightly lower, as were combined sucker values.

Graph IX  
Mercury in Muscle of Fish  
Tennessee River, Mi. 157  
Game Fish, Mean Values



Graph IXa  
Mercury in Muscle of Fish  
Tennessee River, Mi. 157  
Rough Fish, Mean Values



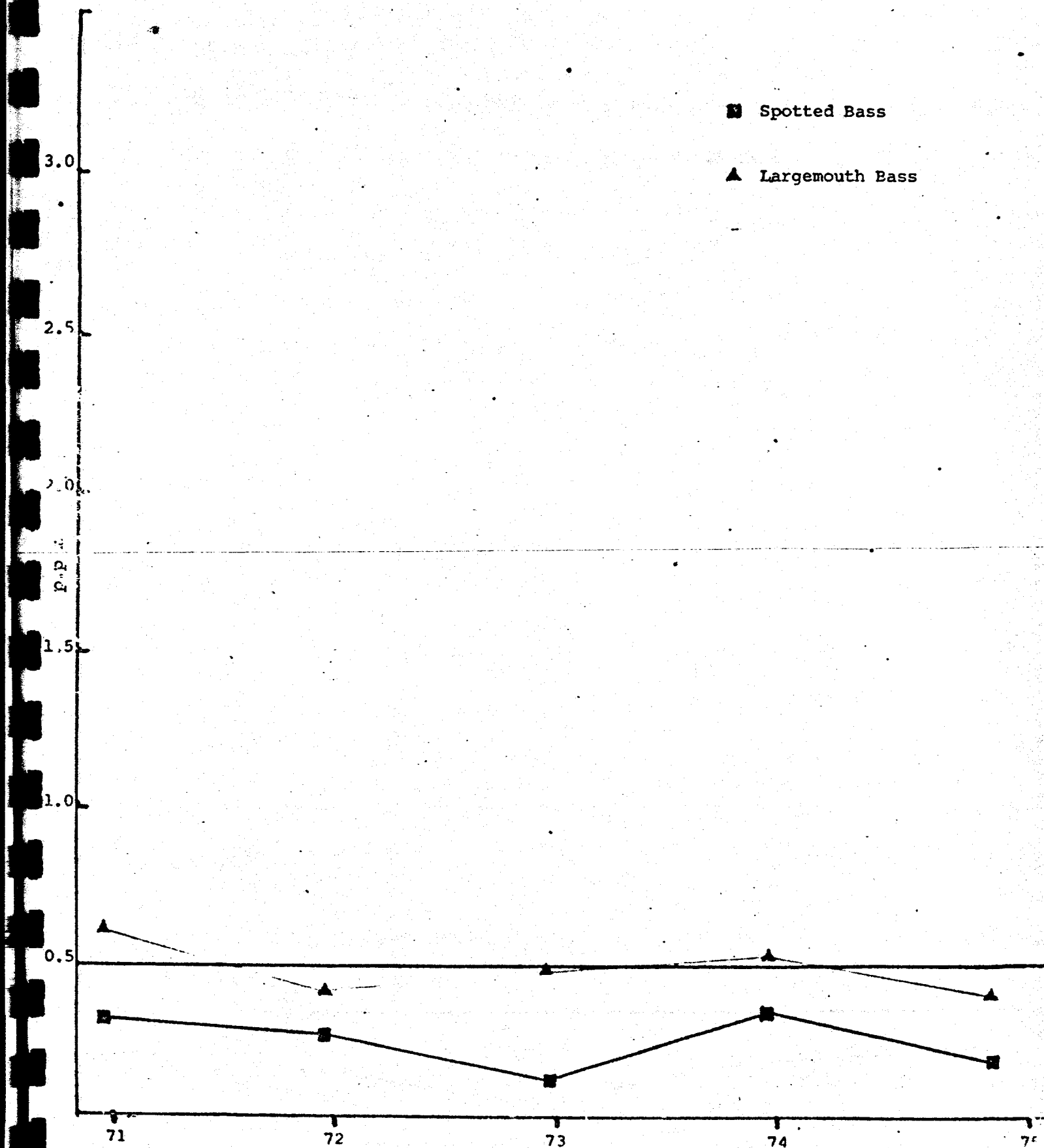
## GRAPH X AND X (a)

## TENNESSEE RIVER, MILE 60

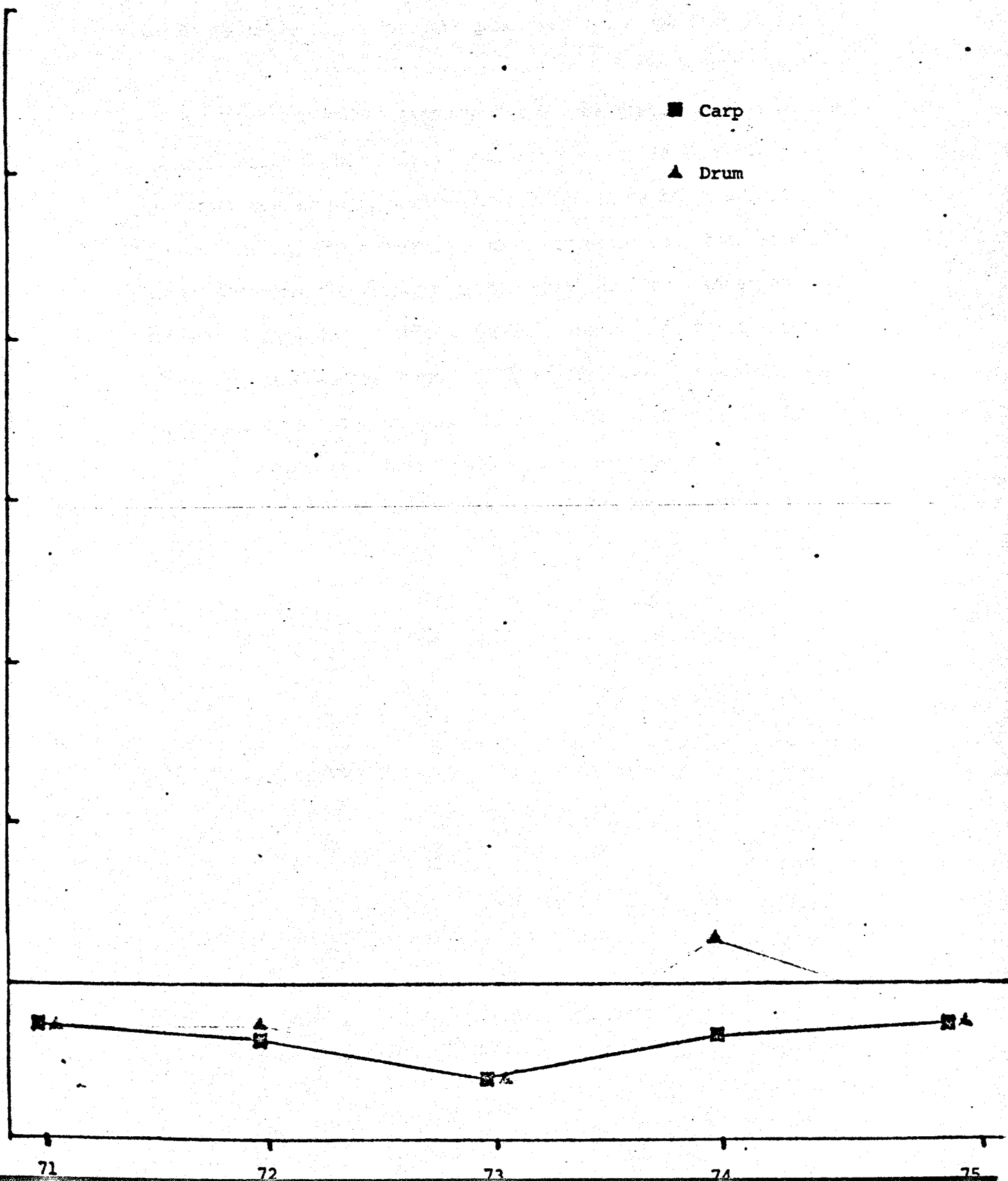
There was little fluctuation in spotted bass mercury level for the five year period; i.e., less than 0.3 ppm with the mean value in 1975 being about 0.1 ppm below the 1971 level. Largemouth bass followed the same general pattern, but were about 0.2 ppm higher. Mean values exceeded the MPL in 1971 and 1974.

Rough fish followed the same general pattern with levels duplicating each other in 1971 through 1975. Drum were 0.3 ppm higher in 1974.

Graph X  
Mercury in Muscle of Fish  
Tennessee River, Mi. 60  
Game Fish, Mean Values



Graph Xa  
Mercury in Muscle of Fish  
Tennessee River, Mi. 60  
Rough Fish, Mean Values



## TABLE II AND III

These tables summarize the game fish and rough fish in a group, showing the percentage that had as much as 0.5 ppm mercury in the muscle, liver and kidney tissues of the game fish, and only muscle tissue of rough fishes. This calculation is based on individuals instead of concentrations other than being above or below 0.5 ppm. At some stations the percentages have decreased somewhat, as will be noted for the muscle tissue from the North Holston. Liver and kidney tissues all exceeded the MPL. A slight increase in mercury concentration at the Hiwassee River and Tennessee River, Mile 490. A perceptible drop based on percentages can be noted at Miles 210 from 41 to 21.7 percent for muscle and 89.8 to 50.09 at Mile 157. I am inclined to believe that these reductions are more apparent than real.

Table II

## Summary of Results of Mercury Analyses of Fish Tissues Exceeding FDA Limits

Source of Samples	Type Fish	Type Tissue	Percentage of Total Specimen Exceeding Limit in		
			1973	1974	1975
North Fork Holston R. Mi. 7.0	Game	Muscle	100.0	88.8	85.7
		Liver	100.0	100.0	100.0
		Kidney	100.0	100.0	100.0
Hiwassee River, Mile 13.0	Game	Muscle	17.0	7.0	21.0
		Liver	0.0	0.0	0.0
		Kidney	0.0	0.0	0.0
Tennessee River, Mile 490	Game	Muscle	13.3	6.7	14.2
		Liver	0.0	0.0	20.0
		Kidney	0.0	0.0	10.0
Tennessee River, Mile 210	Game	Muscle	41.0	18.7	21.7
		Liver	18.0	22.0	25.0
		Kidney	9.0	9.0	4.7
Tennessee River, Mile 157	Game	Muscle	89.8	77.7	50.09
		Liver	65.0	36.3	20.0
		Kidney	35.0	10.0	15.3
Tennessee River, Mile 60	Game	Muscle	35.0	43.7	25.0
		Liver	23.0	14.2	15.0
		Kidney	13.0	14.2	10.0

Table III

## Summary of Results of Mercury Analyses of Fish Tissues Exceeding FDA Limits

Source of Samples	Type Fish	Type Tissue	Percentage of Total Specimen Exceeding Limit in		
			1973	1974	1975
North Fork Holston River, Mile 7.0	Rough	Muscle	83.3	60.0	60.0
		Liver	100		
		Kidney	100		
Hiwassee River, Mile 13.0	Rough	Muscle	0.0	33.3	0.0
		Liver			
		Kidney			
Tennessee River, Mile 490	Rough	Muscle	8.3	0.0	0.0
		Liver			
		Kidney			
Tennessee River, Mile 210	Rough	Muscle	62.5	39.1	21.4
		Liver			
		Kidney			
Tennessee River, Mile 157	Rough	Muscle	44.1	30.0	31.4
		Liver			
		Kidney			
Tennessee River, Mile 60	Rough	Muscle	35.5	32.0	22.2
		Liver			
		Kidney			